The Foundry Trade Journal

AND PATTERN-MAKER.

THE OFFICIAL ORGAN OF THE BRITISH FOUNDRYMEN'S ASSOCIATION.

Vol. 11. **MARCH, 1909.** **No. 87.**

PUBLISHED THE FIRST WEEK IN EACH MONTH.

Subscription Terms: 7s. 6d. per annum, post free.

To place the "JOURNAL" within the reach of Working Moulders and Pattern-makers the Proprietors will accept subscriptions, not less than three in number from one shop, at the reduced rate of **5s.** per annum, such order to be countersigned by the superintendent or foreman.

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THE FOUNDRY TRADE JOURNAL,
165, Strand, London, W.C.

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FORTHCOMING EVENTS.

MARCH 6.

British Foundrymen's Association (Lancashire Branch).—"The Analysis of Pig and Cast Iron," by H. P. Mason.

Birmingham Association of Mechanical Engineers.—"Design and Arrangement of Factory Buildings," by F. Suffield.

MARCH 13.

Birmingham Metallurgical Society.—"Conditions Governing the Production of Steam-Metal Alloys," by Percy Longmuir, B.Met.

MARCH 26.

Birmingham Metallurgical Society.—"Case Hardening," by S. A. Grayson."

MARCH 27.

British Foundrymen's Association (Birmingham Branch).—"Malleable Cast Iron," by J. Matthews.

NOTES AND COMMENTS.

Core-making Compounds.

In a recent article in the "Zeitschrift für Werkzeugmaschinen und Werkzeuge," there is mentioned favourably a process for making foundry cores, which was the subject of a now-expired German patent. It is as follows:—To 75 lbs. dry, well-sifted common building sand there is added 25 lbs. of rather fat core sand, 3 to 4 lbs. each of sifted sawdust and finely-ground coke. All are to be mixed thoroughly and then moistened with a "binder" made by boiling thoroughly 2 lbs. of rice starch in a pail of water, stirring the while. (Merely mixing the starch with water has no effect upon it.) When the sand is well mixed with the hot rice paste, all is well rubbed through a sieve to remove lumps which may have formed, and then allowed to stand a few hours, covered with wet cloths, to let the starch bind well with the sand grains. The rice starch need not be of the best quality. Maize and potato starch are cheaper per pound, but more would be needed. The core-boxes should be well shellacked inside and out, and before they are used should be wiped off with a cloth dipped in petroleum; then very finely-sifted sand should be dusted over the inner surfaces. The cores are vented in the usual manner. Half-cores are joined with the rice paste. If blacking is necessary, as is usually the case, this should be done with a mixture of equal parts of charcoal dust and graphite, thinned down with thin starch paste to facilitate laying on. The cores should be dried at a moderate heat, and under no circumstances be baked. They handle well without breaking, and when once blacked, resist moisture. Excess of heat diminishes the holding power of the starch. Such cores hold together until the iron cools, the starch in the meantime burning with a blue flame. When all is burned out the core may be shaken out, as it neither bakes on nor burns in.

Briquetting Lathe Turnings.

"What to do with the turnings" is an old question the answer to which has not always been satisfactory; but now there seems to be a suitable method of utilising them—namely, by compressing them into briquettes and melting them in the cupola. The trouble has been to get a machine that would compress them sufficiently to hold them together without the use of any bond. There has now, however, developed quite an industry in Central Germany, and especially in Saxony, briquetting cast-iron and steel turnings for the cupola, and wrought-iron turnings for the Siemens-Martin furnace.

One advantage of using these briquettes instead of ordinary cast scrap in the cupola is, for machine shops having their own foundry, that they introduce no "foreign" scrap, but return to the cupola the same material that left it. For these and for other shops, the advantages are that such briquettes are cheaper than good machine scrap; the material is better and more regular in quality, and there is a trifle less loss

in melting than with first-class machine scrap. But the principal advantage is that the resulting castings are denser internally, and much tougher. It is stated that tests show that by using 20 per cent. of briquettes instead of a like quality of machine scrap, the tensile strength is 25 per cent. greater.

The Patents Act at Work.

The passing of the Patents and Designs Act, 1907, has unquestionably made its mark upon the commercial world. Those drastic sections of it which provide for the revocation of patents for inventions the manufacture of which is carried on mainly or exclusively abroad, have stimulated a demand from patentees—both British and foreign—for facilities for establishing the manufacture of their commodities on British soil. There has thus been created a situation of which enterprising companies and others with estates for disposal have not been slow to take advantage.

For instance, to meet the convenience of firms anxious to comply with the provisions of the Act, but who do not see their way to erect factories for the purpose, the Trafford Park Estates, Limited, of Manchester, have laid out an area upon which they are erecting a series of buildings adaptable for ordinary factory purposes, with the advantages of power, light, heat, and fitting shops, added to the railway and deep water facilities which Trafford Park possesses. We understand that the Company are prepared to let these buildings for short or long periods, so that the owners of English patents not already being worked in this country may work them there with up-to-date facilities, without being involved in outlay for buildings or power.

With an eye to the convenience of foreign patentees who may not be prepared to invest in this country the capital necessary for manufacturing their specialities here, a financial concern—Messrs. Steele, Lockhart & Company, Limited—has recently been established under the chairmanship of Lord Grimthorpe, with a view to providing facilities for establishing the manufacture of such patented articles. With this object they have entered into a working agreement with the Trafford Park Estates Company.

Making Ferro-Alloys with Silicon as Reducing Agent.

Interesting results have been obtained from recent Continental electric furnace experiments in making ferro-alloys with silicon as reducing agent in order to reduce the percentage of carbon in the alloy. A furnace of the Héroult type is used with two carbon electrodes suspended in the slag, which is a mixture of 150 to 100 Al_2O_3 and 100 CaO. This mixture is first introduced and fused by turning on the current. The mixture of silicon and the oxide to be reduced is then introduced and the result of the reaction is the reduction of the metal and development of SiO_2, which is absorbed by the alumina lime slag. The reduced metal collects on the hearth of the crucible. In the first experiments a chrome-iron ore containing 31 per cent. Cr and 13 per cent. Fe was reduced by means of silicon in a furnace lined with chromite brick. The silicon used was a commercial high-percentage ferro-silicon containing 91.65 per cent. Si and 1.03 per cent. C. The result of the process was ferro-chrome containing 38.05 chromium, 3.09 per cent. silicon, and 1.56 per cent. C. The high percentage of carbon is perhaps due to contamination of the metal from the carbon electrodes. The percentage of silicon could have been reduced somewhat by increasing the amount of slag used, but in any case some silicon (about 2 per cent.) always passes into the metal or alloy, and this is the weak point of the process. Other experiments were made with chromium, titanium, tungsten and molybdenum.

Next Annual Foundrymen's Convention.

At the meeting of Birmingham Foundrymen, held on January 23, which we report in another page, Mr. R. Mason said that he had noticed from the proceedings of the Council of the British Foundrymen's Association that there was a likelihood of the Congress being held in Birmingham this year. In that case they might hope to make the Convention the best the Association had yet held.

American Foundrymen's Association.

We are informed by the Secretary that the coming Convention of this Association, and its allied bodies, will be held in Cincinnati during the week of May 17, 1909. The meeting days will be on the 18th, 19th, and 20th, while the exhibition of working foundry machinery and equipment prepared by the Foundry and Manufacturers' Supply Association will be open during the entire week.

THE BRASS-CASTING REGULATIONS.

Birmingham Deputation to the Home Secretary.

The Home Secretary, last month, received at the Home Office a deputation composed of representatives of the Birmingham brass industry, including Sir G. Muntz, Messrs. R. G. Evered, J. W. Earle, G. F. Gaywood, A. C. Hawkes, H. A. Potter, J. W. Madely, Mapplebeck, R. Rigby, C. H. Barwell, C. Bedford, G. H. Dugard, H. A. Dugard, and Bagley.

Mr. Jesse Collings, M.P., introduced the deputation, whose object was explained by Mr. R. G. Evered. It was representative, he said, of all the brass and white metal trades and a section of the allied trades of the Birmingham Chamber of Commerce, and the Brass Masters' Association, altogether 220 firms being represented. They wanted some amendment of the draft regulations recently issued by the Home Office for the casting of brass, which dealt with the cubic space required for each caster in the foundries. On this question there had been some difference between the masters and the men, and at a joint Conference a compromise had been arrived at, the cubic space agreed upon being 2,500 cubic feet for sand casting and iron casting. Subsequent to that common agreement being arrived at, a Commissioner came down from the Home Office, and, after making some investigations, adopted the compromise as the basis of the new draft regulations. But these regulations were impracticable and impossible of application, and, if they were insisted upon, it would mean the closing down of the majority of the foundries in Birmingham.

Mr. J. W. Earle complained that the leading brassfounders had not been consulted before the draft regulations were issued, and suggested that if a Home Office official had been sent down to consult with a joint representation of the master and men this difficulty would never have arisen.

Sir G. Muntz also dealt with the impossibility of applying the regulations.

Mr. Gladstone, in reply, said the merits of the case he could not go into, but the fact that a Commissioner had come to certain conclusions did not preclude the Home Office from making such alterations as might be pointed out to them were for the good of the trade. If it were found the Commissioner's report pressed hardly upon the trade it would be the obvious duty of the Home Office to reconsider the position. The system of appointing a Commissioner in such a case had worked well in the past, but he would certainly take into consideration the representation that had been made with regard to holding a joint Conference of all concerned. The specific points which had been submitted would receive the immediate attention of the Department.

CHEMICAL SPECIFICATIONS FOR FOUNDRY IRON.*

By George C. Davis.

Recently attention has been called to complaints concerning the pig-iron specifications drawn up by purchasers.

It is generally agreed that chemical specifications for iron are superior to the old method of grading by fracture. That being the case, it remains to draw up a scheme that is generally recognised.

The blast furnace representatives have attempted to do this, but unfortunately many large purchasers of iron ignore it and have drawn their own. In some cases such restrictions have been imposed that the specifications are practically unworkable; or in other cases no regard has been paid to the iron available in the locality.

Variations in Mixture.

Where one considers the possible combinations by which a mixture can be made it seems to me to be unwise to draw up such specifications for manganese and phosphorus that would exclude many furnaces from bidding when by combining several brands the mixture wanted can be obtained.

I think my point can best be made clear by an illustration from actual practice.

One railroad specifies for No. 1 iron, silicon 2.75 to 4.50 per cent.; phosphorus 0.40 to 0.70 per cent. The silicon limits are wide enough. Presumably the iron is intended for light section castings, and then the question arises, Why so low phosphorus? It so happens that there are a number of furnaces near the lines of this road making a high-grade foundry iron usually running 0.70 to 0.90 phosphorus. Why should they be shut out from competing when by mixing with the lower phosphorus lake ore irons, which are also available, the desired result could be obtained?

Sulphur Content.

Two other railroad companies specify, for No. 1 iron, 0.02 per cent. sulphur or less. Now, can this small amount be determined with such accuracy that the buyer would be justified in rejecting it if it ran slightly higher? The United States Bureau of Standards prepares standardised samples of iron, and in so doing employs the best chemists. One of its pig-iron samples shows a range from 0.032 to 0.036 per cent. sulphur in the results of five chemists; not a great difference, it is true, but suppose there was a like variation on 0.02 iron, who could say which result was correct and whether the iron should be rejected or not?

The blast furnace specifications for No. 1 iron call for 0.03 per cent. sulphur or less in the Eastern and 0.05 or less in the other districts. This is a grade that can be easily made enough below the maximum limit to allow for such variations. As a matter of actual foundry practice, how can such small variations be detected in the casting? This iron is melted with coke, from which it gains from 0.03 to 0.05 per cent. sulphur. An iron containing 0.02 sulphur would then contain from 0.05 to 0.07 in the casting. Under these conditions a variation of a few thousandths of a per cent. in the sulphur contents of the pig doesn't seem to be of much importance.

Manganese.

Another case that came to my notice was a large lot of iron rejected for being 0.001 per cent. below the limit in manganese. Now, this element cannot be determined with such accuracy. In sample C of the Bureau of Standards the manganese reported by five chemists ranges from 0.62 to 0.68. In a standard steel the results by six chemists range from 0.385 to 0.43. If the results of three other chemists who also worked on the sample were included, the variation would be much greater.

It so happened that the transaction referred to took place on a rising market, and the iron rejected had to be removed by the seller when the railroad purchased other iron at an increased price. If the purchaser had bought an additional carload of high manganese iron the whole matter could have been adjusted without loss or delay. In short, too much fussiness about specifications is often costly to the foundry. Other similar disputes have come to my notice, but I think those given illustrate the points made.

In regard to the blast furnace specifications, what seems to me to be needed on the part of consumers is a knowledge of what can reasonably be demanded of the producers, specifications being then so drawn (more especially for phosphorus and manganese) that as many furnaces as possible can compete.

* Read at a meeting of the Philadelphia Foundrymen's Association.

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.—A meeting of the British members of the International Testing Association was held at the Council room of the Iron and Steel Institute, 28, Victoria Street, recently, Mr. J. E. Stead taking the chair and introducing to the members present the newly-appointed representative for Great Britain on the Council of the Association, Mr. G. C. Lloyd, who succeeds the late Mr. Bennett H. Brough. A list of the papers to be read at the forthcoming Congress at Copenhagen was read, and various proposals were put forward for increasing the interest of persons resident in the United Kingdom in the work of the Association. It was pointed out that on the International Committee for reinforced concrete, and on the International Committee for the nomenclature of iron and steel, the representation of Great Britain was inadequate, and it was proposed to ask the Council to add to the first-named Committee two additional members, to be named by the Concrete Institute and by the Institution of Civil Engineers, respectively, and on the latter Committee to recommend the addition of Mr. J. E. Stead and Mr. F. W. Harbord.

A Large Brass Casting.—The pouring of an exceptionally large bronze casting in a single piece was recently carried out at the bronze foundry of the Gorham Manufacturing Company, at Elmwood, R.I., U.S.A. The casting is of the horse which forms part of the equestrian statue of General Sheridan at Washington, D.C., U.S.A. The bronze was melted in more than a dozen large crucibles, and was poured from each of these in turn into a ladle, which finally contained 6,000 lbs. The metal was first poured into a feeding basin in the top of the flask, and when this was filled two plugs were withdrawn and the molten bronze allowed to flow into the mould. The flask was 12 ft. long, 6½ ft. high, and 8 ft. wide, and weighed between 70 and 75 tons before the metal was poured into it. Formerly it has been customary to cast the head and neck of a bronze horse in one piece, the tail in another, the body in two parts, and each leg separately, riveting the parts and then brazing them together.

The Employment of Chill Moulds in Foundry Practice.*

(*Continued from page* 82.)

By E. Leber.

Preventing Cavities and Bubbles.

In another series of castings a compact structure is of paramount importance, and to obtain this the formation of cavities and bubbles must be prevented. Compactness or density is a term of variable meaning among ironfounders, some being content when no cavities or bubbles are revealed when the casting is worked. The case is, however, different when the castings have to be tested or used under pressure. Their behaviour under test varies with the extent of the pressure, and the fluid (water or steam) employed. The resistance to pressure also differs with the medium, since a cylinder may prove quite staunch when tested under steam, water or compressed air, and yet leak in places with carbon dioxide or ammonia, and in all the edges and corners when sulphur dioxide is forced in under pressure Consequently, the number of cases in which the use of chill moulds is highly beneficial is fairly large, especially in castings with a number of lugs and other projections, ribs, passages and bends (Fig. 18).

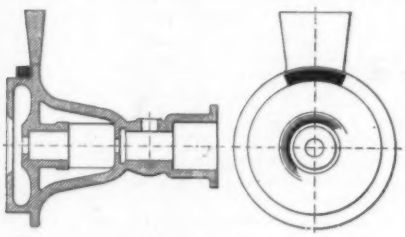


FIG. 18.—CENTRIFUGAL PUMP CASING.

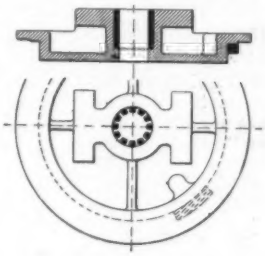


FIG. 19.—LOCOMOTIVE CYLINDER HEAD.

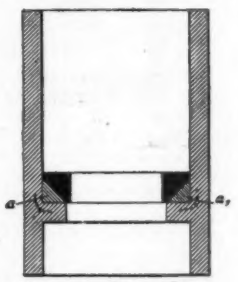


FIG. 20.—VALVE RING.

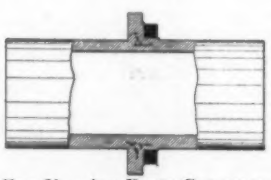


FIG. 21.—AIR PUMP CYLINDER

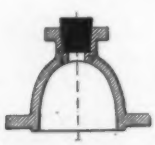


FIG. 24.—VALVE DOME.

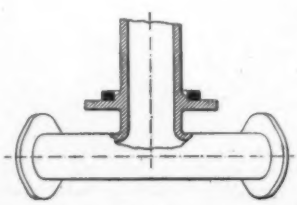


FIG. 22A.—LOCOMOTIVE TEE-PIECE.

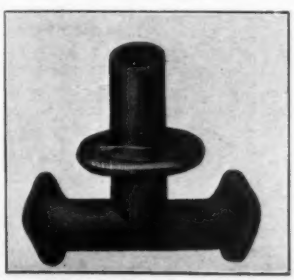


FIG. 22B.—LOCOMOTIVE TEE-PIECE.

The researches into the causes of leaky places in iron have not yet been completed. Those who desire to study these phenomena cannot do better than consult the almost forgotten works of Ledebur (dating from 1869 to 1874) on the subject. Little that is really new has been added since that time, so that the opinion expressed by Ledebur himself in the last edition of his work on the "Metallurgy of Iron" still holds good, namely, that the investigation of the phenomena of the formation of gases in iron is by no means exhausted. The degree of leakiness undoubtedly stands in direct relation to the composition of the metal, since variations occur even in coarse-grained material—a term that is synonymous with permeability as well as looseness of structure. The permeability increases with some kinds of iron, from merely a coarse grained structure, to loose, spongy, and finally porous material interspersed with large cavities. Whilst iron rich in silicon and carbon occupies one end of the series, the coarseness of grain rendering it permeable, iron rich in manganese stands at the other end of the scale, its high degree of shrinkage giving rise to leakiness. In addition, one has to reckon with the bubbles of gas formed from various causes, so that the ironfounder is never safe from the formation of cavities whatever the material he uses.

One kind of cavity to which little attention has been drawn makes its appearance as a superficial depression, which, unlike most instances of this class,

* "Stahl und Eisen."

is not connected with any internal hollow, but is backed by metal that is perfectly compact throughout. The cause is to be sought in the high contraction of the metal, the solidified portion drawing the after pourings so as to fill up the internal cavity and leave only that on the outside. These cases are of most frequent occurrence with metal that is high in manganese, and therefore specially prone to shrink.

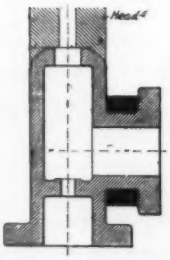


FIG. 23.—REDUCING VALVE FOR COMPRESSOR.

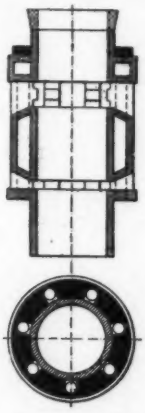


FIG. 25.—SLIDE VALVE BUSH.

Fig. 19 shows a porous patch on the outer periphery of a cylinder head. The chill ring is laid in the inner angle between the flange and the cylinder head, and its action extends right through the metal, so that the weak part is made more compact. The metal is 1 in. thick, the chill four-fifths of an inch thick, and the composition of the iron in an instance known to the author, was that of good machinery iron (0.8 per cent. Mn., 0.5 per cent. P., 1.8 to 2 per cent Si., and 3.3 to 3.5 per cent. C). It should also be noted that a ring of chill rods is inserted in the core for the purpose of increasing the compactness of structure at the piston gland. Fig. 20 represents a simple but very susceptible piece of work, namely, a valve ring for use in locomotives with superheated steam, and requiring to be finished on all sides. It was found impossible to obtain the requisite compactness in the parts marked by the dots, and the direct application of chills in the corners, a and a_1, was impracticable on account of the resulting difficulty in working the metal. Even when these corners were filled up in casting, and afterwards turned out, the porosity was still in evidence, and the only effectual remedy was to arrange the chill as shown in the illustration. The hardened metal in the corners had to be turned out; but it served the purpose of protecting the metal of the ring from over-chilling by keeping the chills at a greater distance. A similar instance is illustrated in Fig. 21 (an air-pump cylinder), as also in the locomotive tee-pipe shown in Fig. 22, with flange for metal packing. Internal projections, such as in the reducing valve (Fig. 23) for a carbonic acid compressor working under a pressure of about 100 atmospheres, are also frequently the seats of cavities. In this case the porosity appeared at the junction of the branch connection; but this defect was completely remedied by introducing a chill ring at the point indicated in the illustration. The parallel examples in Figs. 24 and 25 need no further explanation.

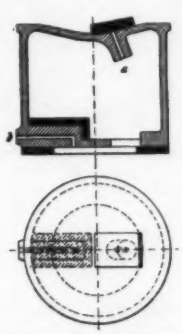


FIG. 26.—OIL TRAP.

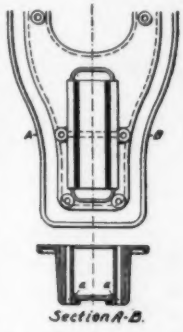


FIG. 27.—CROSSHEAD GUID FOR COMPRESSOR.

In the case of a compressor oil trap (Fig. 26) it was necessary to have the metal perfectly compact at the parts, a and b, for the purpose of boring out the channels to be provided there; but, until chills were employed in the positions indicated in the illustration, the boring tools invariably encountered porous parts.

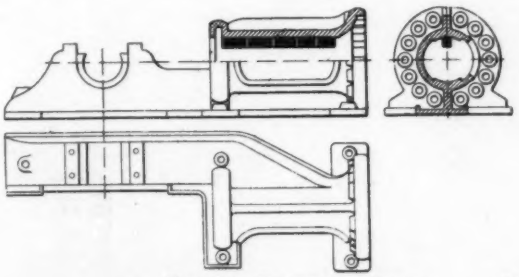


FIG. 28.—CROSSHEAD GUIDE.

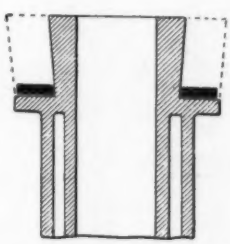


FIG. 29.—AIR COMPRESSOR CYLINDER.

In the guides on the base-plate of a compressor (Fig. 27) the accumulation of metal at the parts, a, caused porosity and spoiled the casting for the purpose in view; this defect was however, remedied by the employment of chills in the position shown. Similar defects invariably occur in cast guides in which there is a strengthening rib exactly over the top part of the crosshead flange (Fig. 28), which defects are undoubtedly due to the rib cooling first and drawing the metal away from the upper part of the casting. The difficulty is overcome by inserting a chill of about the same thickness as the rib in the core. Should there be another rib on the opposite side of the crosshead guide, a second chill is put in there.

Chills frequently do valuable service as substitutes for waste heads on castings; for, though theoretical considerations would incline one to think that a chill placed in the gate or head of the mould would have no effect, practical experience demonstrates the contrary. Thus, in the case of the compressor cylinder shown in Fig. 29, it was formerly the practice to cast this with a large waste head as shown in Fig. 32 *a*, where they act with such effect that no waste-head need be left at all. Fig. 32 *b* shows the finished casting.

The boring out of channels and passages in castings frequently reveals unpleasant defects. Thus, in an air compressor, the parts shown in Fig. 33 *a* were found to be porous, and a number of castings had to be rejected on this account. A remedy was,

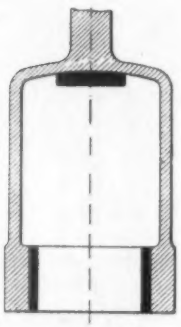


FIG. 30.—CYLINDER FOR HYDRAULIC WINE PRESS.

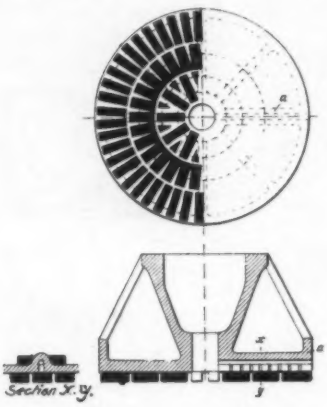


FIG. 31.—PRESS PLATE READY FOR CASTING.

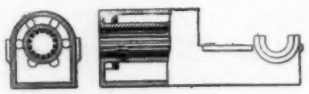


FIG. 33A.—AIR COMPRESSOR BASE PLATE.

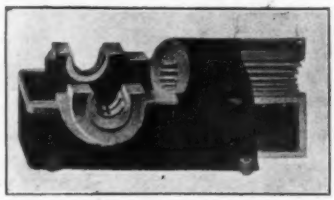


FIG. 33B.—AIR COMPRESSOR.

covering the whole flange, as indicated by the dotted lines, with the result that the cavities formed in the head often extended into the flange. Now, a perfectly compact flange is secured by reducing the size of the head and inserting a chill ring. The case is somewhat different with the hydraulic wine-press cylinder in Fig. 30, the bottom being never sufficiently compact, despite the large risers, until a chill had been inserted as shown. The chill at the head of the cylinder is for rendering the overlying mass compact, so that the requisite deep grooves can be cut into same.

Cavities are also liable to form in the production of large press plates, which, of course, are required to be as compact as possible. A press plate of this kind is illustrated in Fig. 31, from which it will be

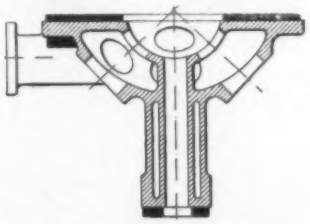


FIG. 32A.—CYLINDER HEAD FOR REFRIGERATOR COMPRESSOR READY FOR CASTING.

seen that the thick ribs above the plate greatly contribute to looseness of texture. The rib, *a*, must also be very dense, a passage for the water having to be bored out through it. This result can be achieved by arranging a number of radial chills in the manner represented.

A well-known source of trouble to the ironfounder are machine parts for refrigerating machinery, especially the compressor heads, a loose texture making its appearance on the flange and between the branches. This has been remedied by placing chills however, afforded by arranging chill rods in the core, in the positions indicated in Fig. 33 *b*. The other chills used are for the purpose of preventing porosity in the lugs provided in the jacket space *b*. Narrow bores, like that in the valve guide bush shown in Fig. 34, are also frequently porous; but a fully compact structure was obtained by setting chills as shown in the illustration. Defects along the lower side of the boring core are by no means uncommon, less on account of shrinkage than from the retention of gas bubbles and impurities by friction against the core, so that the iron solidifies before they can escape. This explains why porosity is also found in cross-heads of guides that are not ribbed like that in Fig. 28. Here again, chills effect an improvement by causing the iron to solidify quickly and driving the bubbles sideways into the mould. It must not, however, be assumed that chills are advisable for all hard cylindrical bodies that become porous underneath the cores when cast in a horizontal position, there being a risk of the cylinder tearing along the chills. An example of

FIG. 32B.—CYLINDER HEAD FOR REFRIGERATOR COMPRESSOR.

this is afforded in the case of locomotive cylinders; and the remedy is to be sought in a modification of the method of casting. On the other hand, chills will prevent the porosity arising from lugs, ribs, etc., in horizontal castings, as can be seen in the superheated steam cylinder reproduced in Fig. 35.

Again, when the castings have to be worked deeply, the tools often get into porous material, which is especially the case in thick castings with thick ribs. An example of this kind is shown in Fig. 36—a piston body—where loose material is encountered in turning out the grooves. When the grooves are

Chills are also beneficial in many castings which are to be milled out of the solid, or contain ribs on wheel rims, as is the case with machine-tool parts, pinions, flywheels, etc. Moreover, it is well-known that pieces cut out of the junction between the spokes and the rim of flywheels, rope, pulleys, etc., show a very low breaking strength in comparison with test bars cast at the same time; and the resulting danger is still further augmented when the metal contains local cavities, both of which defects could be obviated by the use of chill plates, as illustrated in Fig. 39.

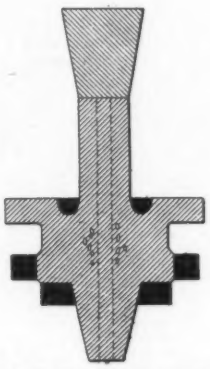


FIG. 34.—VALVE GUIDE BUSH.

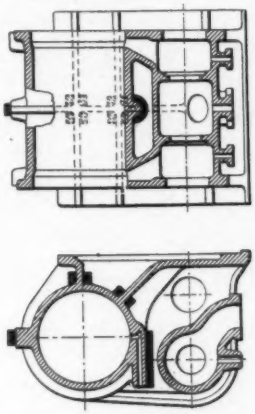


FIG. 35.—LOCOMOTIVE CYLINDER READY FOR CASTING.

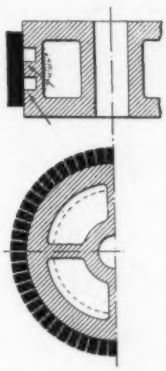


FIG. 36.—PISTON BODY.

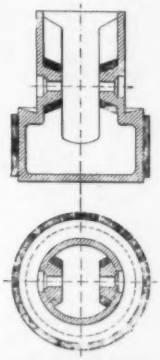


FIG. 38.—DIFFERENTIAL PLUNGER READY FOR CASTING.

made by casting, in order to obviate this defect, the lower surfaces (indicated by the arrows) are irregular. This cannot be improved by leaving a waste-head or thickening the walls, as indicated by the dotted lines; but the insertion of chills all round, as shown in the figure, affords a perfect remedy.

There are many other cases in which the use of chills does good when all other means have failed.

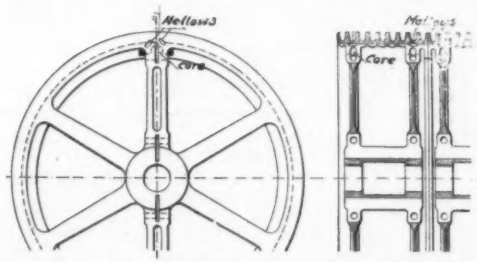


FIG. 39.—ROPE PULLEY WITH SPLIT ARMS.

One of these is the peculiarly-shaped steam chest illustrated in Fig. 37, in which the middle flange and one of the surfaces forming the inner angle could not be obtained in the compact condition essential for use, owing to the number of holes that must be bored into the casting, as shown in the section A, B. The same applied also to the differential plunger, Fig. 38, in which defective places appeared both on the outwardly projecting cylindrical portion and on the internal lugs, though the best cylinder iron was used. At present these plungers are made of machinery iron, chills being used in the moulds in the manner shown in the illustration.

Finally, an example of curing one evil by means of another may be cited. Long castings in which there is an accumulation of metal along one side, always show a tendency to warp. For this reason

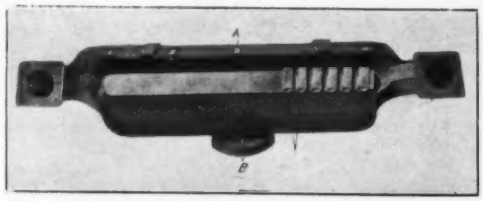
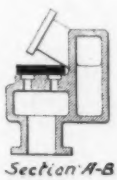


FIG. 37—STEAM.

it is the practice when casting lathe beds, for instance, to place chill plates along the slide prisms (which are underneath in the mould). Ordinarily, these thicker portions of the casting take longest to



cool; but the chills cause them to solidify prematurely, and the stresses thus set up in the metal counteract those tending to make the casting warp.

C

It must not, however, be assumed that chills constitute the philosopher's stone of the ironfounder. On the contrary, there are numerous instances where chills must not be used at all; and even when they are employed their most suitable form and method of application must be seriously considered. For many castings movable chills are suitable; for instance those illustrated in Figs. 13, 16, 17, 28, 31, 33, 37, and 38, which give examples of a variety of segment chills, both bars and blocks. Sometimes it is sufficient to use a simple plate, a bolt, or one or more strips of metal. Large pins, rivet heads, etc., are also useful occasionally. When none of these forms will give the desired result, plastic chills are made by mixing iron filings with sulphite solution, and using the mixture like moulding sand. The chilling action can be lessened by facing the chills with graphite, or sleeking composition, or by embedding them in sand or moulding composition at varying distances from the surface of the mould. There is, however, no need to clean them till bright or wipe them over with oil, as is sometimes done; they may be left in the rough, or if blacked, the graphite should be mixed with sulphite solution to prevent scaling.

Very often, chills, though unable to prevent cavities, can place them into a position where they are not dangerous; and in some cases the whole art consists in employing chills, shaped and disposed in such a manner that the cavities shall be hidden from the person testing the casting, and the casting will pass the tests, in spite of their presence.

Finally, in addition to the great apparent advantages of chills, it should not be forgotten that they frequently enable difficulties that arise from the necessity for grading the metal to be overcome, since they enable the number of mixtures to be reduced, a circumstance of special utility when the number of castings requiring metal of special composition is small.

PREVENTION OF ACCIDENTS IN FOUNDRIES.

Preliminary Report of a Committee of the American Foundrymen's Association.

In connection with the study of accidents in foundries and the ways and means of preventing them, the committee appointed by the American Foundrymen's Association for this purpose thought it best to first gather some statistics on the subject, so that the work might be undertaken with some degree of certainty, and that the recommendations presented to the Association at the coming Convention might be based on actual facts.

In accordance with this decision, a general letter was sent out to practically every foundry in the United States and Canada (6,366 in all), and each letter was accompanied by a blank report to be filled out and returned to the Secretary of the Association.

The time selected was between July, 1907, and July, 1908. Accidents were divided into eleven classes, intended to bring out as nearly as might be the conditions under which they occurred. Further, information was asked on the expense involved to the individual foundry in caring for the unfortunates thus afflicted. Finally, opinions were requested to help the Committee formulate recommendations of value to the foundry industry and the manufacturing interests at large.

To the 6,366 letters sent out 1,084 replies were received, many accompanied with two-page letters explaining the report made, and giving excellent suggestions in relation to the prevention of accidents in foundries. These suggestions will be carefully studied and the summary embodied in the final report of the Committee next May. For the present only the results obtained from the statistical enquiry are given.

Of the returns received, 651 foundries report "no accidents," and the other 433 had a sum total of 5,242, eleven of which were fatal and 424 serious. Of these 433 who had accidents, 345 report the cost to have been £5,967, and one foundry was burned *in toto*.

Of the 1,084 who reported, 190 spent £9,736 for accident premiums; 114 report business for the period in question dull, 302 fair, and 71 good.

One foundry in Pennsylvania reports one man killed a few days before the period specified, as the result of smoking. This accident is not included in the list given, but attention is called to the fact that the use of tobacco may result in an accident on occasion, and probably when least expected. No one else seems to have had any trouble that way, however, many foundries reporting that they do not allow smoking under any pretext. Hence the space provided in the form is omitted in the summary.

Numerous letters contained references to safety devices that had been introduced, and this will be gone into more in detail in the final report of the Committee. A salient feature, however, is the very large number of accidents attributed to personal carelessness. To this should be added some of those classified under unavoidable, as where doubt existed in the minds of the foundrymen in question, the accident was placed into this group rather than in any of the others.

A summary of the totals would be as follows:—

Accident due to—	Slight.	Serious.	Fatal.	Total.	No. reporting	Loss in £.
1. Personal carelessness	1,974	140	4	2,118	123	2,021
2. Careless work	516	39		555	33	924
3. Inattention in shop	227	23		250	19	122
4. Intoxicants ...	4	3		7	4	7 and 1 foundry
6. Unavoidable accidents ...	1,547	159	3	1,709	90	1,372
7. Neglect of safety devices ...	83	7	1	91	9	140
8. Disobedience of orders ...	79	12	2	93	20	706
9. Taking chances	118	24		142	27	419
10. Inferior materials used ...	24	4		28	5	25
11. Employee's ignorance	235	13	1	249	15	227
Totals	4,807	424	11	5,242	345	5,967 and 1 foundry

Anti-Friction Alloys.

British Foundrymen's Association: Birmingham Branch.

By A. H. Hiorns.

The lecturer at this Branch of the British Foundrymen's Association on Saturday, January 23, was Mr. A. H. Hiorns, Principal of the Metallurgical Department of the Birmingham Municipal Technical School, and his subject was "Anti-Friction Alloys; or, Metals Suitable for Bearing Purposes."

The lecturer said that the study of alloys for bearing purposes was of special interest, not only because of its practical importance in engineering and railway work, but also because of the theoretical problems involved. Hundreds of formulæ for bearing alloys had been recommended from time to time, founded largely on guess-work. Charpy held that when a journal was well adjusted the friction was practically the same regardless of the metal in contact, and depended exclusively on the lubricant. If it were possible to keep the journal accurately adjusted, and perfectly lubricated, it would be of little importance what metal they used for bearings, but when these conditions were not perfect, and they were not invariably imperfect, the nature of the metal was a determining factor in the prevention of such accidents as "hot box" and "cuttings." Rennie, as early as 1820, found that in the case of small loads, the co-efficient of friction was at the start practically constant. The increase of friction, therefore, was nearly proportional to the pressure. Above a certain load the coefficient of friction increased rapidly; the surfaces in contact rubbed against each other, become heated, and finally cut, which corresponded to an abrupt, and very great increase in the co-efficient of friction. The load at which rubbing began was generally greater, the harder the metals in contact; the co-efficient of friction, on the other hand, was generally smaller the harder the metal. Hence the use of phosphor bronze. The use of hard substances, however, corrected only the effects of defective lubrication, and assumed that the surfaces in contact were regular. If the metal was hard and unyielding, the pressure on certain points led to heating and cutting. Hence, the bearing metal must have a certain plasticity, so as to mould itself round the shaft, and increase the surface of contact. But the bearing itself was constantly wearing away irregularly, and the plasticity of the metal must be such as to restore constantly its contact with the shaft.

Therefore, they had to seek in alloys for bearings, and for machinery subjected to friction, two apparently contradictory characteristics, namely, hardness and plasticity. These, however, might be combined by using metals composed of hard grains embedded in a plastic matrix, and this was the main principle aimed at in anti-friction alloys. The composition of the alloy, therefore, was of prime importance, because on this the structure largely depended. Alteration of the structure by heat treatment was possible, but was small under the conditions in which a bearing was used. Defects, however, causing excessive heating in the bearing, might arise through the metal being unduly heated for casting. These defects were segregation, coarse crystalline structure, oxidation products, and inclosed gases. Segregation was often due to improper proportions of the constituents, especially with copper-tin-lead alloys in which excessive heat had been introduced. Coarse crystalline structure, due to various well-known causes, such as the presence of impurities or the excess of ingredients added as deoxidisers, brought about a loss of ductility and durability. Moreover, under these conditions, the bearing became unduly heated.

It was with the idea that hardness of surface reduced the co-efficient of friction that copper-tin alloys were formerly used for heavy loads and high speeds. In order to get proper adjustments, a lead lining was introduced by Mr. Hopkins, and the practice of lining bearings had now become general. Mr. R. Job, in discussing suitable bearings for railway work, stated that he found that the alloy with the highest tensile strength and elongation gave increased life to the bearing, and a lessening of wear. The compressive strength, of course, was important, for the alloy must be hard enough to support the load without deformation. If it were too brittle, it would crack under the pressure; if sufficiently plastic, it would keep cool even under exceptional conditions.

The essential points in a bearing metal were:—Composition, structure, friction, temperature of running, wear on bearings, wear on journal, compressive strength, and cost. No one alloy would reach perfection in all these requirements. For example, the metal showing the lowest rate of wear might have the highest co-efficient of friction and *vice versâ*. The combination must be studied in detail, and the qualifications of each balanced against the others according to the special features required.

The lecturer then, with the aid of lantern views, described the composition and structure of various alloys for bearing metals.

Lead and Antimony.

Lead and antimony, he said, alloy in all proportions, and as the antimony increases the alloy becomes harder and more brittle. The only proportion free from segregation is the eutectic with 13 per cent. antimony. With less antimony they had crystals of lead and eutectic. With more than 13 per cent. antimony they got crystals of antimony and eutectic. The required condition of hard grains in a plastic matrix was best fulfilled in these alloys by those having above 13 per cent. antimony (eutectic), and those with 15 per cent. to 25 per cent. were the most suitable. But in the alloy with 13 per cent., while the friction was higher the wear was greatly diminished, and where pressures were light this was a great advantage. Lead was the best wear-resisting metal known, and with increasing antimony the wear was more marked, though the friction became less, and the temperature of running diminished. The compressive strength increased rapidly on the addition of antimony, but varied little between 14 and 30 per cent. antimony, though afterwards it rose steadily; but the crystals of antimony, which in a higher percentage became more united and bore a portion of the load, had no plasticity, so that when the load reached a certain limit, the alloy was reduced to fragments.

Lead-Tin-Bismuth.

Lead-tin-bismuth alloys might be divided into three groups, according to the metal deposited first. There were no chemical compounds. In an alloy of lead 21, tin 5, and bismuth 74 per cent., the bismuth

probably solidified below 175 degrees C. Surrounding these crystals were areas of bismuth and tin eutectic, and a matrix consisting of a ternary alloy of a complex eutectic nature.

Tin-Copper-Antimony.

In ternary alloys of tin, copper and antimony (Babbitt metal), very rich in tin, they would find crystals of tin, and these would not have the requisite properties for bearings. Charpy found the alloy 83 per cent. tin, 11½ per cent. copper, and 5½ per cent. antimony to possess the greatest compressive strength, and this was used by several railway companies for car bearings. The best alloys should be at least within 3 or 4 per cent. of this composition. In the case of some of these alloys, it had been found possible to double the compressive strength by quick cooling. Alloys with high copper, of course, were costly. Babbitt metal was easily made by melting the copper first under a layer of charcoal, then adding a portion of the tin and stirring with a charred stick. The antimony was next added, and finally the remainder of the tin. The whole was then vigorously stirred. When the temperature had been lowered to about 500 degrees C., the alloy was cast into the mould, which should be previously warmed, preferably to about 100 degrees C.

Lead-Tin-Antimony.

Dealing with lead-tin-antimony alloys, Mr. Hiorns said that lead and antimony did not readily combine, and when the antimony exceeds 13 per cent., hard grains of antimony appear. Both lead and tin being soft, the properties of lead-tin alloys vary little with composition. The compressive strength increases by addition of either metal, with the maximum strength in the eutectic alloy. The compressive strength was greatly raised by addition of antimony, and was least with those containing an excess of lead. In order to avoid brittleness the antimony should not exceed 16 to 18 per cent. To get the highest compressive strength the alloys containing over 15 per cent. were best.

Lead-Copper-Antimony.

Lead and copper, the lecturer said, only alloy in small proportions, and when large proportions are used, the metals separate on cooling, each containing a little of the other. But copper and antimony alloy in all proportions with the formation of at least one definite compound which crystallises in needles of a violet colour. This compound also enters into the composition of the eutectic alloy, and increases its resistance to compression. If too much copper is added, it induces segregation like copper and lead alone. An alloy of 65 per cent. lead, 25 per cent. antimony, and 10 per cent. copper is used for packing for locomotives and tenders.

Zinc-Tin-Antimony.

Zinc and tin do not readily combine, hence, crystallites of tin or zinc are found embedded in a eutectic containing about 10 per cent. tin. Alloys of zinc and antimony form a definite compound which is hard, and this forms the eutectic with 2 per cent. zinc. Ternary alloys in which zinc predominates, are probably formed of zinc, tin, or antimonide of zinc. As there appears to be no ternary compound formed, these alloys may be divided into three groups, according as the zinc, tin, or antimonide of zinc crystallises first. Only the last possesses properties suitable for anti-friction purposes. Alloys with excess of zinc have a very high compressive strength, and tin diminishes the brittleness. Alloys of zinc are liable to brittleness when heated, and are little used except when low price is esteemed.

Copper-Tin-Lead.

Bronzes are often used for bearings, and may be classed under two heads :—(1). Alloys of copper and tin, with only small quantities of other elements (P, Zn, etc.). (2) Alloys of copper, tin, and lead, which are frequently used. With yellow-copper-tin alloys, the compressive strength is greater than that of white alloys, and increases regularly with the proportion of tin. Phosphorus does not seem to have any marked influence in this respect. Alloys of copper and tin, with up to 20 per cent. of tin are the same in structure. Phosphorus, when present, is localised in the eutectic, modifying its hardness. The eutectic is much stronger than pure copper, and it is this which regulates the compressive strength of the mass. The addition of lead increases the plasticity, leaving trails of a plastic substance in the midst of the metal. Copper-tin-lead is now the chief alloy for standard bearing bronzes. The added lead is a great advantage because it is less liable to heat under the same lubrication, and the rate of wear is diminished. The following table is by Dudley, of the Pennsylvania Railway Company :—

Metal tested.	Composition.					
	Copper.	Tin.	Lead.	Phosphorus.	Arsenic.	Relative wear.
Phosphor-bronze standard ...	79.70	10.00	9.60	0.80	—	1.00
Ordinary bronze	87.50	12.50	—	—	—	1.49
Arsenic bronze "A"	89.20	10.00	—	—	0 80	1.32
,, ,, "B"	82 20	10.00	7.00	—	0.80	1.15
,, ,, "C"	79.70	10.00	9.50	—	0.80	1.01
Bronze "K" (1)	77.00	10.50	12.50	—	—	0.92
,, (2)	77.00	8.00	15.00	—	—	0.86

Dudley concludes :—I. Phosphorus and arsenic exercise no marked influence on wear, and are useful only for sound castings. II. The metal which wears out the least is the one capable of undergoing the greatest distortion before breaking. III. The rate of wear decreases with the increase of load.

Clamer, of the Ajax Metal Company, in 1903, gave the following table as the results of tests made with different alloys.

Copper and tin, and copper, tin, and lead series.

	Copper.	Tin.	Lead.	Friction.	Temperature above room.	Wear in grains.
1 ...	85.76	14.90	—	13	50	0.2800
2 ...	90.67	9.45	—	13	51	0.1768
3 ...	95.01	4.95	—	16	52	0.0776
4 ...	90.32	4.62	4.82	14	53	0.0542
5 ...	85.12	4.64	10.64	16½	55	0.0380
6 ...	81.27	5.17	14.14	18½	58	0.0327
7 ...	75 (?)	5 (?)	20 (?)	18½	58	0.0277
8 ...	68.71	5.24	26.07	18	58	0 0204
9 ..	64.34	4.70	31.22	18	64	0.0130

The conditions in all the above described tests were as follows :—

Total number of revolutions made, 100,000.

Revolutions per minute, 525.

Size of journal, 3¾ in. diameter, 3½ in. long.

Pressure per square inch in pounds, 1,000.

Lubrication. Galena and coal-oil fed by cotton waste.

The best alloy adopted by Clamer for general purposes was : Copper 64, tin 5, lead 30, and nickel

1 per cent. What is true of alloys with less than 15 per cent. lead, is also true of high-lead content alloys, namely, the rate of wear diminishes with increase of lead, or, in other words, the rate of wear diminishes with the diminishing compressive strength or increased plasticity. Zinc bronzes may be cheap, but zinc increases the rate of wear, and tends to segregate lead. The constitution of bronzes is the reverse of that of white alloys. Instead of hard grains in a plastic eutectic we have soft grains in a hard eutectic for the same degree of plasticity. The behaviour of bronze and of white metals is not identical, and the bronze has a greater tendency to cut.

When the oil is driven out, owing to increasing load, and the metal becomes heated, the wear in the case of white metal is then considerable, and if the load continues to increase, the alloy may be partially fused. In the case of bronze, the portions rich in copper adhere to the shaft, forming a rough surface and increasing the friction.

Bronzes, then, are inferior to white metals because —they are less plastic and do not mould themselves so well around the axle; their greater strength does not permit a heavier load, for then the lubrication is interfered with, and the bearing tends to become heated. Bronzes, on account of their constitution, have a greater tendency to cut than white alloys, and thus produce a deterioration of the axle.

Summing up, Mr. Hiorns, said :—An anti-friction alloy should have hard grains in a plastic matrix; then the load is carried by the hard grains which have a low coefficient of friction, and the cutting can only take place with difficulty. The plasticity of the alloy makes it possible for the bearing to adjust itself round the shaft, thus avoiding local pressure, which is the chief cause of accidents. Such properties may be obtained in binary alloys with such metals as antimony, tin, and copper, which form chemical compounds. They are better obtained in ternary alloys, which give a good plastic matrix (eutectic). To test an anti-friction alloy, compression and the microscope are invaluable aids.

Discussion.

Mr. F. J. Cook (President of the National Association), said he believed that the rate of cooling had been made the subject of a patent for white metals for lining bearings. The usual thing now was to have the casting made round a mandril in the shape of a tube through which immediately after starting the casting, water was run, and in some cases very good results had been thus obtained. Where high temperatures had to be withstood, as in packing for steam engine pistons that were subjected to superheated steam, it was found that the addition of nickel was a very great improvement. He did not understand how this was, because he should expect nickel to form another hard kind of crystal. Copper and lead did not easily mix, and in slow cooling, at all events, easily got separated. If the lecturer could give them some idea of the best method of mixing, say 70 copper, 25 lead, and 5 per cent. nickel, it would be very useful.

Mr. W. B. Parker (Rugby), said that with respect to the biting of shafts, the speed had a very great influence, because at a high speed the same spot on the shaft passed over the same spot in the bearings a greater number of times, and caused heating to be more rapid. Nowadays, they were constantly called upon to provide for speeds of as high as 3,000 revolutions per minute, and some of the shafts carried very heavy loads, so it was necessary to force the lubricant between the shaft and the bearing in order to keep a constant film of oil and so cut down the effect of biting.

Mr. Gaywood thought the French engineers had been very much more successful than the English with phosphor-bronze bearings, and he had been very much struck with the manner in which they ran the lubricating curves in their bearings. The white metals, of course, had attained a great amount of success because they bedded themselves to the shaft. With regard to quick cooling, casting in chilled moulds as at present practised was in use forty years ago.

Mr. F. J. Cook did not agree with Mr. Gaywood that with perfect lubrication phosphor-bronze was more generally used. To-day perfect lubrication was obtained by means of forced lubrication, but the bearing most generally used was cast-iron lined with white metal.

Mr. Reason said that the only occasions on which he had found phosphor-bronze useful was when he had had a difficult case to contend with, when a great strain had to be withstood.

The President, in thanking Mr. Hiorns for his lecture, said that the question of the effect of the rate of cooling was really a very important one, and they were rightly paying more attention to it than formerly. They were thus deviating from the strict following of the analysis, but there was no doubt that in cooling and crystallisation very great effects were produced. With regard to phosphor-bronze, he remembered being told some years ago by Mr. Hiorns that he had analysed some phosphor-bronze for a gentleman who was very much surprised to find that there was no phosphorus in it. But it was quite possible that the phosphorus had been there, and having done its work had gone off in the slag.

Mr. Hiorns, replying, referred to some questions that had been put about the effect of nickel. Nickel, he said, of course, was a hard metal, and hardened other metals with which it alloyed, particularly copper, copper itself being a soft metal. If they had an alloy of copper, lead, and nickel, the lead would separate out from the copper and they would then get practically a hard metal. The rest might be an isomorphous mixture, as if they had all copper and all nickel. Mr. Gaywood and others had referred to analyses showing 0.8 per cent. of phosphorus. That was a great deal more than was required for deoxidation. The proportion varied according to the purpose for which the metal was required: in some cases it was 0.1 per cent. or less, in others, 0.5 per cent., in others 0.8 per cent. Also the hardening effect did increase with the proportion of phosphorus. Presumably, therefore, with these alloys with 0.8 per cent. of phosphorus there would be a hardening effect. A certain amount of the phosphorus would act as a deoxidiser, and the remainder would tend to harden the alloys, forming a chemical compound with the copper. Mr. Buchanan referred to a bearing which turned out badly, and which therefore was regarded as having been originally bad. It was not necessarily so; it might be that it was not the mixture that was wrong, but the workmanship. A gentleman once told him of a bearing that had worked very badly: when the man employed to cast bearings was asked if he had made the proper mixture, and melted it properly, he replied: "Yes." "Did you lose anything?" The man replied: "Nothing." The manufacturer, after a little while came back, and said: "Where did you put the stuff you skimmed off that metal?" In the end the man said: "Well, I saw some hard lumps sticking up, and I threw them out." (Laughter.) This, of course, accounted for the missing ingredient and for the unsatisfactory state of the casting.

The Girod Electrical Process for the Manufacture of Steel Castings.

A Swiss Installation.

The machinery firm of Oehler & Company, at Aarau, Switzerland, who are makers of iron and steel castings, have a crucible steel plant of the ordinary kind, which has been replaced since August 1 last by a Girod arc furnace, with the most satisfactory results. The furnace has a capacity of two tons, and requires 400-h.p. As similar plants have been erected for the John Cockerill Society, in Belgium, for steel for ordnance purposes; for Stoss, in Stuggart (Southern Germany), for small steel castings; and for the Ternitz Steel Works, in Austria, for machinery steel, the success of the furnace, and the commercial advantages of the process, appear now to be beyond question.

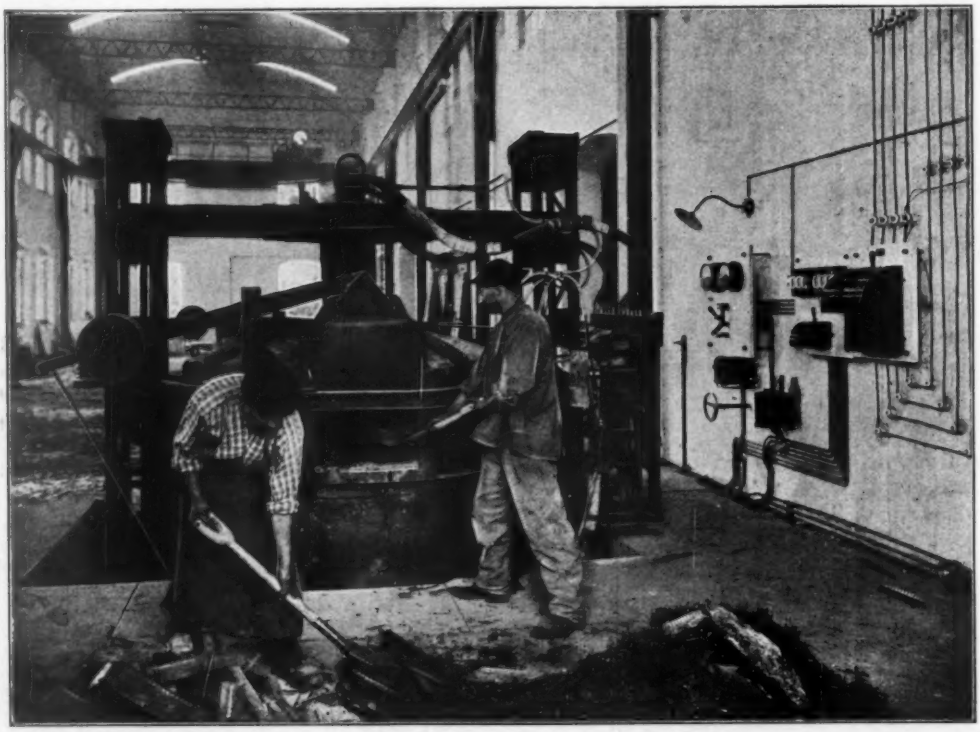


FIG. 1.—TWO-TON GIROD ELECTRIC STEEL FURNACE AT THE WORKS OF MESSRS. OEHLER & COMPANY, AARAU, SWITZERLAND.

In the Swiss plant the furnace is 6 ft. 8 in. inside diameter, 20 in. high inside, and is electrically tipped and regulated. The automatic electrode regulator, by H. Cuenod, of Geneva, raises and lowers the electrode passing through the roof, so as to keep the current at the desired strength. The lining is of magnesite. The electrode is 14 in. square by 60 in. long, all in one piece. It weighs 440 lbs. at starting, and lasts sometimes 10 charges, but on the average 5 to 7.

In operation, charging takes about one hour, and when the current is turned on it takes five hours more, until the charge of 3,300 lbs. is ready for pouring, with a current of 5,500 amperes at an average of 55 volts. At present two heats a day are run, but three could be easily obtained if the furnace were run continuously. A typical charge is:—Pig-iron, 580 lbs.; turnings, 330 lbs.; scrap iron and steel, 1,010 lbs.; return scrap, 935 lbs.; lime, 130 lbs. Besides these, varying quantities of ferro-manganese, ferro-silicon, and aluminium are used, according to the needs of the charge.

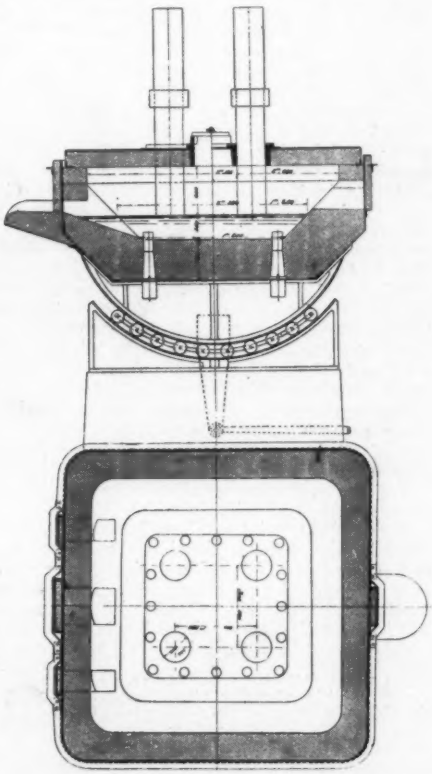
A typical analysis of the steel, which is run into small castings, is:—Carbon, 0.53 per cent.; silicon, 0.474 per cent.; manganese, 0.275 per cent.; sulphur, 0.017 per cent.; phosphorus, trace.

Ninety-eight per cent. of all castings are good, even in the case of the smallest and thinnest castings, and their long experience in making crucible-steel castings enables this firm to obtain castings as clear as ordinary foundry castings. The average tensile strength obtained is 80,000 to 90,000 lbs. per square inch, with elongation 5 to 10 per cent. It is estimated that the electrical part of the plant has an efficiency of 75 to 80 per cent.; that is, that 75 to 80 per cent. of the energy of the primary current appears as heat in the furnace.

Description of the Furnace.

The hearth of Girod's electric furnace consists of a circular or oblong cavity, in which the

metal when molten reaches a depth of from 10 in. to 12 in. One or more electrodes of a like polarity are fixed above the bath, and pieces of soft steel embedded in the hearth of the furnace and in direct contact with the molten metal form the negative electrode. The electric current, entering by way of the upper electrode, forms an arc between itself and the bath, traverses the bath and passes out through the lower pole pieces; the upper parts of the lower pole pieces, which are in direct contact with the metallic bath, become molten at their extreme ends; but their length is not decreased by more than 2 in. or 4 in., as has been proved by examining such pieces after several months' work. With a view to reducing the length of the fused part, and also preserving the lower lining of the furnace intact, the extreme lower ends of the pole pieces are water-cooled by means of a cavity about 6 in. deep in that part



of the piece which projects outside of the furnace frame; on this projection is likewise the device for leading the current to the poles.

According to the capacity of the furnace there are one or more electrodes above the bath, but whatever their number they are all mounted in parallel and connected to the same terminal of the machine, the other terminal being connected to the metallic pole pieces.

Operation by Resistance.

The Girod furnace is therefore comprised within the class of arc furnaces, but it likewise operates in part by means of resistance to the passage of the current through the metallic mass; this feature is of great importance at the outset of the operation when the current is directed upon the cold charge of scrap, pig-iron, etc.; the entire mass is then traversed by the current, and almost the whole of the difference in voltage at the terminals of the furnace is absorbed by the resistance of the charge, which is then very great, and by an endless number of small arcs forming between the adjacent pieces. Heating and melting therefore begin and proceed in the entire mass simultaneously. The great facility of starting with a cold charge has been found to constitute a marked advantage in electric furnaces, particularly as compared with arc furnaces with electrodes in series in which the passage of the current is localised in a narrow strip on the surface of the mass to be treated.

The Construction of the Furnace.

The furnace is formed by a metal, *i.e.*, sheet-steel, framework of circular or rectangular section, which is lined with refractory material (generally magnesite). A charging and working door, and also a tap hole, are provided in the walls; and the steel is made to flow out by tipping the furnace, which is for this purpose mounted on pivots or on a cradle. The roof is made from silica bricks built around cast-iron pieces with inside independent water circulation, through

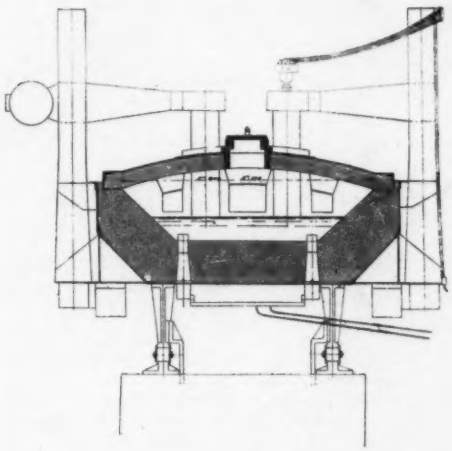


FIG. 3.—SECTIONAL VIEWS OF GIROD ELECTRIC STEEL FURNACE. CAPACITY, 8 TO 12 TONS; POWER, 1,200 KILOWATTS.

which pass the electrodes. The electrodes are adjusted in such a manner that the air cannot make its way into the furnace; this adjustment, and the use of the cast-iron parts, are rendered possible by the fact that there are no electrodes of different polarity, and consequently no short circuit to be feared through the cover.

As previously stated, the automatic regulation of the electrodes is easily effected. This regulation is effected on the voltage when the furnace of smaller capacity, say, 2 tons, has a single electrode and is fed by a generator; it is, however, made on the intensity of current wherever the furnace has an electrode fed by a transformer or several electrodes all supplying current equally.

Output.

The electric furnace has an extremely wide range, and can be used for manufacturing steels of all kinds —carbon steels from the mildest to the hardest, and special steels of every variety, whether for tools or structural purposes. An important feature is the

great purity and homogeneity of the metal produced, as also is the possibility of avoiding the occlusion of gases in the metal, owing to the work being done without access of air in a furnace completely closed and constantly under pressure. The very high temperatures which it is possible to obtain must likewise be regarded as of great importance. They allow, for instance, the use of highly basic refining slags, and impart a considerable briskness and intensity to the reactions. In particular the very high degree of freedom from sulphur and phosphorus which it is possible to obtain in the electric furnace may be ascribed to the high temperatures. With the increase of temperature, in fact, the chemical equilibrium between the slag and molten metal is altered all in favour of the purification of the bath.

The Operative Methods.

The course followed in all operations consists in fining the metal by sufficient additions of iron ore until an exceedingly soft metal is obtained (maximum

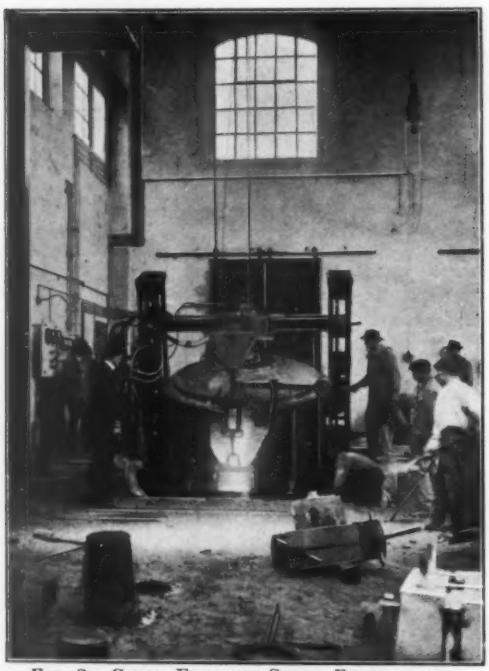


FIG. 2.—GIROD ELECTRIC STEEL FURNACE IN ACT OF POURING.

C. 0.075, Si. 0.05, Mn. 0.05). This result having been obtained by the action of successive oxidising slags, the latter are replaced by highly calcareous slags which rapidly produce complete dephosphorisation, and simultaneously promote the elimination of the sulphur. The extra mild and pure metal thus obtained is then treated to give it the required degree of quality, an operation comprising on the one hand the deoxidisation of the bath, and on the other hand its recarburation. Suitable additions, *e.g.*, ferro-silicon, silico-manganese, ferro-chrome, ferro-tungsten, nickel, etc., are then added, so as to obtain steel of the desired composition. Desulphurisation occurs during the entire operation, but particularly in the last phase when the slags are practically free from the oxides of iron and manganese. The most varied steels are thus made in the Ugine Works, in France, where for about two years a furnace of 35 cwts. capacity has been working. The accumulated experience now enables a complete adjustment both of the electro-thermic operation of the furnace, and the course of operations from the metallurgical standpoint, to be made.

Production Costs.

The consumption of power per ton of steel produced is from 800 to 900 kilowatt-hours at the terminals of the furnace (a power corresponding to the loss of voltage between the upper part of the electrode and the lower part of the poles); therefore, allowing for 10 per cent. loss in the conductors, a consumption of about 1,000 kilowatts at the generator can be reckoned on, it being understood that a steel of superior quality is being produced from unsorted iron and steel scrap of the cheapest kind.

In the case of the mere smelting of a charge of a given composition, as in the crucible furnace, the consumption may vary between 650 and 750 kilowatts, but then the extra cost of the raw materials exceeds the saving in power. The final composition of the steel likewise plays an important part in the number of kilowatt-hours consumed per ton. These figures as to consumption are the result of the operations of the Ugine furnace absorbing 275 kilowatts, and having a capacity of 35 cwts. In high-power furnaces with a greater capacity, the consumption in kilowatt-hours per ton of steel smelted and fined or only smelted diminishes, it is claimed, to a considerable extent. Should liquid steel from an open-hearth or Bessemer furnace be charged in the electric furnace it would be necessary to expend, for refining and giving the exact quality to the metal in the electric furnace of 35 cwts. capacity, about 350 kilowatt-hours per ton, which consumption may be diminished to about 250 or 300 kilowatt-hours, according to the capacity of the furnace and the nature of the product to be refined and obtained.

The consumption of electrodes when starting with scrap as raw material amounts to about 4s. per ton of steel produced. It falls in refining a liquid charge by about 1s. 6d. per ton of steel.

For the management of a 3-ton furnace a melter, an assistant, and a boy would be necessary.

The following interesting figures have been compiled by the makers, showing the cost of melting a ton of steel in a 2-ton Girod electric furnace.

In the case of a cold charge of scrap iron and turnings to be completely refined, with a view to obtaining high-quality steel, the following average cost of melting must be reckoned:—

	s.	d.
2 cwts. of lime, 2 cwts. of iron ore with the addition of various alloys ... ... 3s. to	3	5
Electrodes	4	0
Labour	4	9
Upkeep of furnace, wear and tear of plant (pokers, ladles, &c.)	12	0
Power, 1,000 kilowatt hours (according to cost)	—	

If the mere melting of a charge of a defined composition be carried out without any refining the costs are appreciably reduced, and there must be allowed about the following:—

	s.	d.
Lime and fluxes	1	0
Electrodes	3	2
Labour	3	2
Upkeep of furnace, wear of plant	9	6
Power about 750 kilowatt-hours (according to cost)	—	

For refining a charge of liquid steel from the Bessemer converter or open-hearth furnace in the electric furnace, the various costs fall to:—

	s.	d.
1 cwt. of lime and various additions, 1s. 2d. to	2	6
Electrodes	1	7
Labour	2	5
Furnace upkeep, plant wear	4	0
Power about 300 kilowatt-hours (according to cost)	—	

The Up-to-date Foundry.

Notes on the Construction and Equipment of a Typical Modern American Foundry.

By Dr. R. Grimshaw.

The high price of labour in America has long ago led to the use of castings where otherwise forgings would have been chosen; this, again, together with the greater softness of American cast iron, permitting its more ready working, has gradually led to improvements in the science and art of casting, enabling further substitution of cast for forged metal.

Owing to these circumstances the average American foundry differs widely from those of other countries, where the conditions are different. Naturally, no two foundries are alike; but there are some general features of design and construction which may be adopted in building almost any new foundry where the object is fully known. This is not always the case, for often a foundry is built to satisfy existing and growing—also changing—local demands, and under such circumstances founders are glad to take what is offered.

Among the broad general principles which should govern the design of any foundry is this, that there should be easy access for heavy supplies, as of pig, coal, coke, sand, and flux, and good facilities for the removal of slag, ashes, and large castings. A second is, that as far as possible all materials—raw, half-manufactured, or ready for storage or shipment—should flow in only one direction, so that no time is lost and no labour expended in moving them to-and-fro, or even zig-zag, when straight-line movement is practicable. A third is that so far as possible such movement shall be continuous; that is, that no delays or blocks shall be caused by half-finished material waiting in its course to be further manipulated.

Where the foundry products are intended only for further manipulation in machine-shops belonging to the same establishment, it is desirable that the "straight-line" feature be carried out still further, so that after the chipping, pickling, sand-blasting, and tumbling processes the castings shall enter at one side of the castings stock room, to be delivered therefrom at another, preferably the one directly opposite the reception side.

The term "straight-line" must be capable of a certain elastic interpretation; thus, for instance, running along two sides of an "L" may be considered as straight-line or direct-line passage, as distinguished from to-and-fro or zig-zag movement.

A fourth principle is that the establishment must be extensible on short notice, and at minimum expense, preferably in some one direction, without sacrificing any one of the three previously-mentioned points.

It may be assumed as of prime necessity, that the plant shall have good transportation facilities by either rail or water, preferably both.

The best materials for the building are brick and steel. Plenty of light must be admitted through large windows, commencing at such a height above the floor as not to interfere with moulding and other operations.

One of the best styles for building is the "step-roof" plan, consisting of a high main nave and two side ones of lesser height, with clerestories entirely of glass. Where the building is of great width there may be a central nave with clerestories, then each side of this one of medium height, and flanking these, two of still lower roof, light being admitted by four clerestories. The main roof may be provided with a louvre for ventilation.

There is no objection to a flat roof carried on steel trusses, and with skylights arranged on the saw-tooth plan, giving north light and no shadows.

The modern foundry usually has overhead track cranes, although there are many served by single post jibs at or near each corner, in such positions, and with such reach, that each can deliver to any of the others.

For handling patterns, moulds, and castings there may be small hand cranes with pneumatic hoists, and running on the lower roof-truss chords. This permits bringing the iron to the floor by the trolley system (mentioned later on) and handling the ladle while pouring, by the travelling crane. In this way one crane is never in the way of the other.

In some foundries there are at every column connections for gas, water, or compressed air.

Where heavy casting is done, it is usually done in the centre if there be more than one bay; lighter floor work being done each side thereof, and bench moulding along the wall. Core-moulding, if called for, should be done in a separate department convenient to the pattern shop, and fitted with sand-sifting and mixing and core-making machines, core-drying ovens, and storage room for cores of standard sizes and shapes.

Convenient to the workmen's entrance there must be a locker room for clothing, and suitable washing facilities. The water-closets can be in this part, so simplifying the water service. The metal yard should be commanded throughout its entire length by an electric crane, say, of 10 tons capacity. The coal for the furnaces should be in bins so placed as to facilitate firing. If light flasks are used there must be a yard for storing them, and they can be run about by an overhead trolley rail. The carpenter's shop for making large flasks can adjoin the pattern shop, but no patterns or parts thereof should be made therein.

For storing coal and coke, the material may be loaded into boxes, which the crane places on a car running on a narrow-gauge truck on a trestle over the bins.

To ensure getting dry sand instead of that which may have come from a wet place, or have been transported in wet weather or in a leaky boat, it is well to buy in dry weather, especially in July and August, and to get enough to last until the next dry season. There is no sense in buying sand containing 10 per cent. of water, and paying for it by the ton.

Bearing in mind the four general principles enunciated above, we find that the central point of interest in the foundry is the cupola, or air furnace, about which may be grouped three elements having direct connection therewith or relation thereto: (1) The stores of pig, scrap, limestone, and coke; (2) the steam-boiler, engine, dynamo, air compressor, and blower; and (3) the moulding floor. The minor stores of moulding- and core-sand, core-oil, rye flour, graphite, etc., should more strictly adjoin the moulding floor, on the other side from the melting end. From the heavy store, where the pig may be kept in

stacks, and the coke, scrap, and flux in bins, there should be a track with necessary turn-tables to the charging point, and scales to permit the accurate weighing of each material, and good writing facilities for recording in duplicate on suitable blanks the data concerning each charge. One copy of each form should be kept by the "heavy-storekeeper," the other sent with the charge to have added thereto the necessary data concerning duration of melt, time of tapping, amount tapped, weight of good and of bad castings, etc. All prices should be filled in at the office; the foundry proper having to do with weights and time only. At the cupola the data concerning duration and pressure of blast, etc., may be added on the blanks.

The cupolas, or air furnaces, if more than one be used, should be of different capacities, say, one of 10, one of 20, and one of 30 tons. The air furnaces may be charged from the metal yard, their charging doors being even with the partition wall.

The cupola may be charged from the metal yard; the charging floor being of liberal dimensions and under the yard crane-way. For convenience, the pig charges may be weighed up and noted in the yard, and the scrap charges on the charging platform, which also should have good coke-storage room. Instead of a vertical elevator, material may be raised to the charging floor by an inclined runway and an electrically operated cable. At the foot of the incline is placed the weighing-scale, and each car is run directly from the incline to the furnace mouth. Where there is elevated land on one side or at one end of the foundry, the expense of the inclined runway can often be much lessened by using the natural grade to bring up the melting materials, etc.

In one American foundry, at least, the cable which runs the car up to the charging floor is also used to operate the "monkey" in the stock yard for breaking up large pieces of metal, and to unload scrap from railway cars; it is attached to the gripping-tongs rope in the latter case, to the drop rope in the former, by a snatch-block.

It is a good plan to get all iron upon the charging floor before charging begins. The coke may be put on this floor by an endless chain and bucket elevator from the ground level. Another way is to have a coke-storage bin, containing some months' supply, and filled by an elevator; its floor being on the same level as the charging floor. The sand, sea-coal, and fireclay storage bins may come under this coke bin.

The cupolas may be charged by hand, or there may be used hydraulic charging machines, each serving two cupolas, thus cutting down the labour bill for the charging floor.

Where chilled rolls are broken up and used, every roll so scrapped should be analysed and numbered, and its record kept, so that in making up a charge the roll section required can be found.

It is sometimes found advantageous to put the blower room on a mezzanine floor underneath the charging platform, thus reducing to a minimum the length of the requisite blast-pipes. In at least one American foundry the blower is on top of the engine house.

Next to the cupola, on one side, may be the ladle-drying oven, much like a core-oven, and used for both large and small ladles. It should be open on both ends, so that those ladles which have been in the longest may be the first taken out.

Expeditious carrying and pouring of the metal is most important. An excellent method is by ladles hung from roller-bearing carriers, running on an overhead steel track made of two sections of steel sheet bent at right angles and placed facing each other thus []; the pendant carrying the load passing through the central slot. The general system of overhead tracks may run parallel to the travelling cranes, but may have numerous cross tracks, so that the full ladles may run from the cupola down one main line and over a cross track, and the empty ones go down the other main line back to the cupola for re-filling. The moulds in the cross rows may be either in a double or a single row.

If moulding-machines on wheels are used, the overhead track arrangement must be different; in such case there may be three sand rows, and the machines go down one passage and back up the other, leaving a row of moulds on each side. With this arrangement there will be two double overhead lines, one for the right-hand mould row, another for the left. In each, the ladles will go full down one track and return empty up the other.

For rapid working, ladle No. 1 is filled and run down the track; ladle No. 2 catches the flow without stopping off, and so on. Each ladle is run down the track and poured from. If the track be short the empty ladle can be run along to the end and back; if long, there should be frequent cross-tracks with suitable switches, so as to get the empty No. 1 ladle off the down track to the up line before No. 2 comes down. Another way, in case the pouring is too fast for the moulding on one line, is to run odd-numbered ladles on the left-hand down track and those with even numbers on the right-hand one.

Heavy work, if any, may be left to the last. The overhead trolley-tracks serve to take the castings to the cleaning rooms. By the use of such trolleys one man can handle 500 lbs. of metal as easily as 100 by hand. The furnace-ladle pits should be under the foundry-crane run. The large ladles can be of the "bottom-pour" type, such as are usual for steel pouring; they deserve to be more used in iron foundries.

We may assume that in our up-to-date foundry moulding-machines will not be absent; and under the further assumption that the greater part of the castings will be comparatively small will arrange for the use of a number thereof. But instead of having them fixed in a row along the side or sides of the moulding floor, they should, as in a rule, be on wheels. The reason is, that it is cheaper and more convenient to have a pile of sand the length of the foundry axially, and to run the moulding-machines down one side and up the other, leaving moulds behind, than to carry empty flasks to the machines, and full ones from them to where they are to be poured. In further recognition of the principle that everything unnecessary is to be avoided, the smaller flasks, instead of being of iron, should be of cherry or other hard wood on the "snap" plan; one or two going with each machine, so that when the mould is made the flask is removed from around it, leaving it ready for pouring.

After shaking out the castings the larger ones may be taken to the cleaning room by the trolley, which runs slightly down grade, so as to favour the full ladles and the castings. Smaller ones are put into boxes and trollied to the cleaning department. Scrap, sprues, and gates are put into boxes and trollied to the elevator leading to the charging platform, and there delivered; there being on the platform a small trolley track with chain hoist for unloading the scrap boxes.

In the cleaning department are rattle-boxes, sand-blast, pickle-vats, grinding-stands, and a dry cinder-mill for cleaning the dump. Around the cleaning barrels there are trolley tracks. The sand blast and pneumatic chipping chisels may be served by an electrically-driven air compressor, the motor being in or next to the cleaning room; or the air may come from the engine-room compressor, used to operate the pneumatic hoists. If chilled cast iron dust be used in

the blast apparatus, it will be found more satisfactory than sand.

Match-boards are made of dust from the tumblers mixed with linseed-oil (only a small amount at the time, as the mixture sets rapidly); no litharge is necessary.

The core-ovens should open at both ends—into the core department and the moulding floor—so that the core wagons can be pushed right through, the driest cores being first used.

The larger core-oven can have shelves around the sides, and one or more cars on a track down the middle; the doors at each end being counterbalanced so as to be easily opened. The ovens are lighted by an electrical lamp at each end in front, with a reflector throwing the light clear to the other end. The core-ovens may be heated by coke fires, or, where convenient, by hot gases. Where core wagons are heavy, they may be moved by a snatch-block attached thereto, and to one end of the hoists.

A modern improvement in pipe foundries is to pass the moulds, after being rammed, over coke fires in the pits, and dry them before the cores are set. The coke stoves extend two-thirds of the circumference of the pit, and the gases pass up through the moulds, which partially serve as chimneys. After the moulds are dry the cores are set and the moulds are poured. In the meantime, other flasks which have been shaken out are being rammed. Thus, instead of drying the moulds at night and pouring the next day, the mould is finished, and the casting made, within a little over three hours.

The pattern-shop must be flooded with light. It is well to have at one end of the room a large wall cabinet for pattern-makers' tools. Here there may be a number of wooden leaves, "book-fashion," both sides of which are fitted with racks, clips, etc., for the reception of tools.

It is sometimes feasible to put the pattern-storage department over the cleaning room and flask shop. It must have a stout fire-proof floor, and be completely cut off from the foundry by fire-proof doors. The windows should be of wire-mesh glass. The shelves for small patterns should be adjustable on brackets held by pipe columns. Heavy patterns are stood on the floor.

The flask shop must be provided with work-benches and tools for making and mending both wooden and metal flasks.

POISONOUS EMANATIONS OF FERRO-SILICON.

A report of the result of an inquiry into the cause of death of five Russian immigrants, who alone occupied the steerage of the s.s. "Ashton" during a voyage of some 24 hours from Antwerp to Grimsby, which latter place was reached on December 13, has been issued by the Laboratories of the Royal Institute of Public Health. The ship carried a cargo of ferro-silicon, any gases from which could obtain easy access to the compartment occupied by the deceased. In the course of investigations at the Laboratory, the following experiments on animals were undertaken, viz.:—(1) A small quantity of ferro-silicon was placed in the bottom of two glass jars, being moistened in the one case, but left dry in the other. Into each of these jars a mouse was then placed, resting on a piece of wire-gauze placed some distance above the substance. Both mice showed marked symptoms of dulness and somnolency, and the one before death disturbances of movement. The mouse over the moistened ferro-silicon died in four and a-half hours, whilst the one over the dry substance lived. (2) Four mice placed in a larger jar over moistened ferro-silicon also died within from six to ten hours. (3) Four guinea-pigs when placed over the moistened substance under similar conditions, died within ten hours. (4) A guinea-pig placed over a quantity of dry ferro-silicon also died, but this was possibly accounted for by the ferro-silicon becoming moistened with the animal's urine. These animal experiments prove that ferro-silicon, when moist, readily evolves gases which are fatal to life.

In order to determine what gas is mainly evolved when ferro-silicon is moistened, the following experiments were made:—(*a*) Two hundred grammes of the powdered and moistened substance were placed in a horizontal glass tube, 19 in. long and 1 in. in diameter. This tube was connected with another tube about 11 in. long and ½ in. in diameter, and filled with small pieces of potassium hydrate in order to absorb any sulphuretted hydrogen. Air was then gently drawn through the tube for about three hours and allowed to pass through a 10 per cent. solution of silver nitrate contained in a De Koninck absorption apparatus. A dark precipitate was immediately produced in the silver solution, and at the end of the period was considerable in amount.

(*b*) Experiment (*a*) was repeated, with the exception that the potassium hydrate tube was removed and ammoniacal cuprous chloride solution substituted for the silver nitrate. As no precipitate was formed in the copper solution it is evident that acetylene is not formed under these conditions.

(*c*) Experiment (*a*) was repeated, but in this case the gases were passed through nitrite acid. The acid solution was evaporated almost to dryness, hydrochloric acid added, and the mixture evaporated to complete dryness. The addition of hydrochloric acid and subsequent evaporation to dryness was repeated and the residue dissolved in distilled water, when no trace of insoluble silica was found. Silicon hydride is, therefore, not evolved from moistened ferro-silicon at ordinary temperatures. Having excluded acetylene and silicon hydride from the gaseous mixture, there remains the possibility of phosphoretted and arseniuretted hydrogen.

(*d*) Some of the silver solution obtained in experiment (*a*) was filtered and the filtrate, which would contain arsenic (if present in the gases) as arsenic acid, was introduced into a Marsh-Berzelius apparatus, with the result that a slight mirror was obtained after prolonged heating. Some of the precipitate was then introduced into the apparatus, when the characteristic phosphorus flame was immediately produced, being most marked, and this, in spite of the facts that the heating of the glass tube was continued, which would tend to decompose phosphoretted hydrogen, and that the flame was burning at the end of a tube not furnished with a platinum jet. It is, therefore, evident that although arseniuretted hydrogen is produced in small quantities, the chief gas evolved is undoubtedly phosphoretted hydrogen, a gas which is stated to be so poisonous that 0.02 per cent. of it in air is fatal to small animals within half an hour.

Gearing and Gear Patterns.

By William Ashcroft.

The theoretically perfect gear wheel is a friction wheel communicating a perfect uniform rolling motion by means of frictional contact to its surface. It is a wheel having a great number of very small, weak, regular teeth. The object of the science of gearing is to increase the size and strength of the teeth without destroying the uniformity of motion transmitted; to do this the outlines or shape of the teeth must be formed to have the desired result. There are many ways of getting these outlines theoretically, but I wish to deal only with those methods which are used in pattern shop practice. There are two kinds of teeth which are used almost universally, and are described in this article as the involute tooth, and the odontograph, or cyclodical tooth. The spur gear is one with teeth parallel to its axis; it is used for transmitting motion from one shaft to another, the axis being parallel. Bevel gears are those used to transmit motion between shafts at right angles to each other, the shafts being in the same plane. The teeth of these gears must necessarily be at an angle to the axis. Mitre gears are similar to bevel gears having an angle of 45 degrees to the axis, and are used for transmitting motion between shafts at right angles, in which the number of revolutions of the two shafts are the same.

When two wheels act upon each other the greater is termed the gear and the lesser a pinion. The circular pitch is the distance between centres of adjacent teeth measured on the pitch circle, and is obtained by dividing the circumference of the pitch circle by the number of teeth required. The diametral pitch is the number of teeth in a gear divided by the number of inches in the diameter of the pitch circle. The thickness of a tooth is its thickness measured on the pitch circle. The space between two teeth is the space measured on the pitch circle. The addendum is that part of a tooth which is outside of the pitch circle. The dedendum, or root, is that part of the tooth inside of the pitch circle. The clearance is the difference between the thickness of tooth and width of space and also the difference between the addendum and dedendum when in gear.

When the circular pitch is given, to obtain the diametral pitch divide 3.1416 by the circular pitch. Therefore if P is the circular pitch, p the diametral pitch, D diameter of the pitch circle, and N the number of teeth, diametral pitch, $p = \frac{3.1416.}{P}$

When the diametral pitch is given, to obtain the circular pitch, divide 3.1416 by the diametral pitch: circular pitch, $P, = \frac{3.1416.}{p}$

When the number of teeth and circular pitch are given to obtain the pitch diameter, multiply the circular pitch by the number of teeth, and divide the product by 3.1416, so: Diameter of pitch circle, $D = \frac{P \times N}{3.1416.}$

When the number of teeth and diametral pitch are given, to obtain the pitch diameter, divide the number of teeth by the diametral pitch: Pitch diameter $= \frac{N}{p}$

When the pitch diameter and the circular pitch are given, to obtain the number of teeth, multiply the pitch diameter by 3.1416 and divide by the circular pitch: Number of teeth, $N = \frac{D \times 3.1416.}{P}$

When the pitch diameter and the diametral pitch are given, to obtain the number of teeth, multiply the pitch diameter by the diametral pitch: Number of teeth, $N = D \times p$.

When the pitch circle and number of teeth are given to obtain the diametral pitch, divide the number of teeth by the pitch diameter: —

$$\text{Diametral pitch} = p = \frac{N}{D}.$$

Readers may find the following tables of service to them. The first gives the equivalent diametral pitches for circular pitches from 2 to $\frac{1}{8}$ in., and the second gives the equivalent circular pitch for diametral pitch from 1 to 40.

Circular pitch.	Diametral pitch.	Circular pitch.	Diametral pitch.
2 ins.	1.5708	$\frac{3}{4}$	4.1888
$1\frac{3}{4}$	1.6755	$\frac{5}{8}$	4.7124
$1\frac{7}{8}$	1.7952	$\frac{1}{2}$	5.0265
$1\frac{1}{2}$	1.9333	$\frac{3}{8}$	6.2832
$1\frac{1}{4}$	2.0944	$\frac{1}{4}$	8.3776
$1\frac{1}{8}$	2.2848	$\frac{3}{16}$	9.4248
$1\frac{1}{4}$	2.5133	$\frac{1}{8}$	12.5664
$1\frac{1}{8}$	2.7925	$\frac{3}{32}$	15.7080
1	3.1416	$\frac{1}{16}$	18.8496
$\frac{7}{8}$	3.5904	$\frac{1}{32}$	25.1327

Diametral pitch.	Circular pitch.	Diametral pitch.	Circular pitch.	Diametral pitch.	Circular pitch.	Diametral pitch.	Circular pitch.	Diametral pitch.	Circular pitch.	Diametral pitch.	Circular pitch.
1	3.1416	$2\frac{1}{2}$	1.1424	8	0.3927	15	0.2094	22	0.1428	29	0.1083
$1\frac{1}{4}$	2.5133	3	1.0472	9	0.3491	16	0.1963	23	0.1366	30	0.1047
$1\frac{1}{2}$	2.0944	$3\frac{1}{2}$	0.8976	10	0.3142	17	0.1848	24	0.1309	32	0.0982
$1\frac{3}{4}$	1.7952	4	0.7854	11	0.2856	18	0.1745	25	0.1256	34	0.0924
2	1.5708	5	0.6283	12	0.2618	19	0.1653	26	0.1208	36	0.0873
$2\frac{1}{4}$	1.3963	6	0.5236	13	0.2417	20	0.1571	27	0.1163	38	0.0827
$2\frac{1}{2}$	1.2566	7	0.4488	14	0.2244	21	0.1496	28	0.1122	40	0.0785

Involute Teeth.

The involute curve is the curve which would be drawn by a pencil point fastened at the end of a band drawn tightly while being unwound from a round body. The basis of the involute system is a rack, for which a wheel having 135 teeth is taken as an equivalent. The method for constructing the involute curve of a single curve tooth, geometrically, is shown in Fig. 1, where A is the centre and B C the pitch

Fig. 1.

line. On line B C mark points D, E, F, G, H, equal distances apart, drawn lines through each of these points meeting at centre A; from E, F, G, H, draw lines tangent to the circle B, C, and at right angles to A E, A F, A G, and A H, respectively. With E

as centre and E D as radius mark, point I on line drawn tangent from E, with F as centre and F D as radius, mark joint J on tangent line drawn from F, and so on till the four points I, J, K, and L through which a curve is passed called the involute curve.

A very convenient and much more practical method is to form the curve from a base line which is drawn inside of the pitch circle according to the desired angle of obliquity. The base line of a 15-degree involute tooth is inside the pitch circle a distance equal to $\frac{1}{57}$ of the pitch diameter, and the base circle of a 20-degree involute tooth is inside the pitch circle equal to $\frac{1}{100}$ of the diameter of the pitch circle. Instead of using the aforesaid measurements for the base circles of a 15-degree or 20-degree involute tooth, the geometrical method shown in Fig. 2 can be used, by which the base circles and the radii for a 15-degree or 20-degree tooth are given. With A as centre and A D as radius, draw pitch circle B D C, bisect A D at E and with E as centre draw semi-circle D F A; from A draw two lines at the angles of 15 and 20 degrees to A D, and passing through semi-circle D F A at G and H respectively. Now with G as centre and G D as radius, draw the involute curve with an angle of obliquity of 15 degrees, and

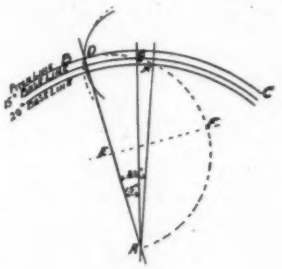


Fig. 2.

with H as centre and H D as radius, an involute curve can be drawn with 20 degrees as the angle of obliquity. The A G and A H will be the radii for the base circles of involute teeth with an angle of obliquity of 15 and 20 degrees respectively. Another, and, perhaps, more practical method, is given in Grant's treatise on gearing, which gives an involute odontograph table with radii for various sizes of gears:—

Table I.—*The Grant Involute Odontograph.*

Teeth.	Divide by diametral pitch.		Multiply by circular pitch.		Teeth.	Divide by diametral pitch.		Multiply by circular pitch.	
	F. Face radius.	G. Flank radius.	F. Face radius.	G. Flank radius.		F. Face radius.	G. Flank radius.	F. Face radius.	G. Flank radius.
10	2.28	0.69	0.73	0.22	24	3.64	2.24	1.16	0.71
11	2.40	0.83	0.76	0.27	25	3.71	2.33	1.18	0.74
12	2.51	0.96	0.80	0.31	26	3.78	2.42	1.20	0.77
13	2.62	1.09	0.83	0.34	27	3.85	2.50	1.23	0.80
14	2.72	1.22	0.87	0.39	28	3.92	2.59	1.25	0.82
15	2.82	1.34	0.90	0.43	29	3.99	2.67	1.27	0.85
16	2.92	1.46	0.93	0.47	30	4.06	2.76	1.29	0.88
17	3.02	1.58	0.96	0.50	31	4.13	2.85	1.31	0.91
18	3.12	1.69	0.99	0.54	32	4.20	2.93	1.34	0.93
19	3.22	1.79	1.03	0.57	33	4.27	3.01	1.36	0.96
20	3.32	1.89	1.05	0.60	34	4.33	3.09	1.38	0.99
21	3.41	1.98	1.09	0.63	35	4.39	3.16	1.39	1.01
22	3.49	2.06	1.11	0.66	—	—	—	—	—
23	3.57	2.15	1.13	0.69	36	4.45	3.23	1.41	1.03

Table II.—*The Grant Involute Odontograph (continued.)*

Teeth.	Divide by diame ral pitch.	Multiply by circular pitch.
37—40	4.20	1.34
41—45	4.63	1.48
46—51	5.06	1.61
52—60	5.74	1.83
61—70	6.52	2.07
71—90	7.72	2.46
91—120	9.78	3 11
121—180	13.38	4.26
181—360	21.62	6.88

Fig. 3 illustrates the method of marking off an involute tooth by means of this odontograph table. First draw down the pitch line; inside of this line and at a distance equal to 1-60 of the pitch diameter, mark the base line. On the outside of the pitch circle

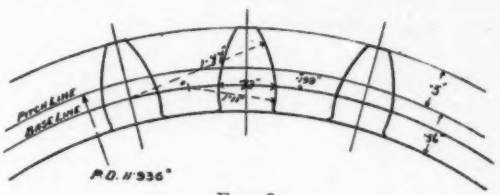


Fig. 3.

and at a distance equal to 1-3 of the circular pitch mark the addendum line, and inside the pitch line mark the dedendum equal to $1\frac{1}{8}$ of the distance the addendum is from the pitch line. Now divide the pitch circle into the number of teeth required, that is 25, and the circular pitch will be found to be $1\frac{1}{2}$ in.

Referring to the odontograph table opposite the figure 25, and under the heading of face radius, will be found the figure 1.18; this multiplied by the circular pitch will give the radius for the face of the tooth. In the present instance the radius will be 1.77 in., and by setting compasses to this size and making the centres on the base line, the form of the teeth on the outside of the base circle can be drawn.

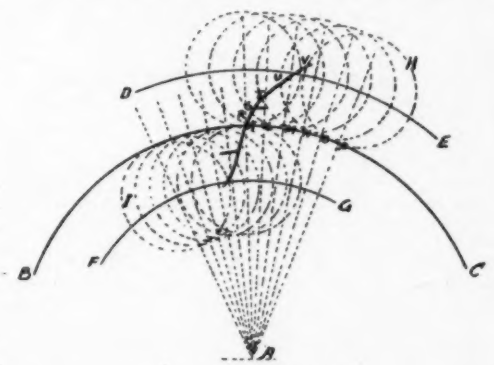


Fig. 4.

Again referring to the table opposite to number 25, and under the heading of flank radius, the figure 0.74 is given; this multiplied by the circular pitch gives 1.11 in., so with 1.11 as radius, and the centre on the base line, the form of the teeth can be finished.

Cycloidal Curve Teeth.

The cycloidal system, unlike the involute, has for its basis a pinion, and there is no limit to the sizes of the wheels which may be used. The principle of the

double curve tooth is that of cycloids formed by rolling circles. A method for marking out the cycloidal curve is shown by Fig. 4.

With A as centre describe B C as part of pitch circle. Upon it rolls two circles, called generating circles. The outer one H describes the epicycloid curve, and the inner one, I, describes the hypocycloid curve. The diameter of these generating circles must be taken as the basis; that is, the smallest pinion, which is in gear, must not be smaller than these circles, for then the teeth would be smaller at the root and so take away part of their strength. For general purposes we may safely take the diameter of the generating circles to be double the pitch; although this is not essential, there are cases when they would need to be smaller, but only on rare occasions. With A as centre, describe D E, giving the centres for circle H at a distance equal to the pitch on the outside of B C; describe F G the same way only on the inside of B C. Taking the outer circle H first, mark off D E into a number of equidistant divisions, and

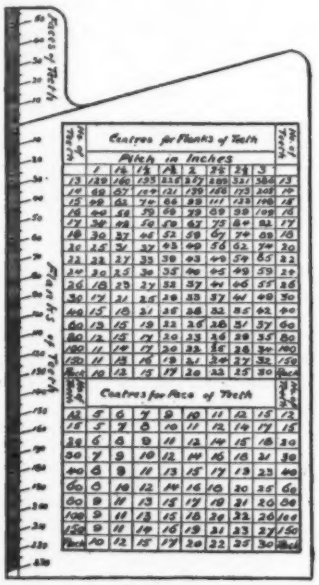


FIG. 5.

mark a line through each of them meeting at centre A, and cutting B C at K, L, M, N, O, and P. Describe circles H with centres, as marked off on D E. Now with distances L K, M K, N K, O K, and P K mark L R, M S, N T, O U, and P V, respectively, as shown in sketch. A line drawn through these points K, R, S, T, U, V, gives the true epicycloidal curve. The hypocycloid curve is obtained in a similar manner, only the generating circle moves in the opposite direction to the one used on the outside.

The principle of rolling circles, although geometrically correct, is very unpractical in the workshop; that being so it is necessary to have some method to do away with the rolling circles, and yet have the same shaped tooth. For this purpose an odontograph has been formed, a copy of which is shown in Fig. 5. Readers will notice that this scale gives the radii for the flank and face of the tooth. Although this method does not give an absolutely correct cycloidal curve, seeing that the rolling circle does not describe a true curve, yet for all practical purposes this odontograph can be used without any doubt, as the best and quickest method for the workshop. Anyone who may have this class of work to do at any time is advised to make an odontograph similar to Fig. 5. A suitable one is 14 in. long, 6 in. wide, and $\frac{3}{16}$ in. thick, made with hard wood; plane tree, maple, or hornbeam being very clean and smooth are suitable. From the working edge and near to one end mark a line 75 degrees. From this line, which is called zero, mark off a number of $\frac{1}{2}$-in. divisions at each side of it, each of these divisions are again divided into ten equal parts. The part of the scale which is on the left-hand side of the zero line, looking from the marked edge, is for the face of the tooth, or that part which is outside of the pitch circle, and the other larger part of the scale is for that part of the tooth which is inside of the pitch circle.

The method of using this scale is shown by Fig. 6, which represents a wheel having fifteen teeth of $1\frac{3}{4}$-in. pitch.

With A as centre describe an arc representing the pitch circle. On the inside and outside of this arc describe temporary lines for the teeth required; mark line D A passing through pitch circle to the centre A. From the point where D A cuts the pitch circle mark the pitch $1\frac{3}{4}$ in., draw a line through this mark to the centre, as C A, and then bisect the angle C A D by the line B A, cutting the pitch circle at G. From this point mark off the pitches for the teeth. The

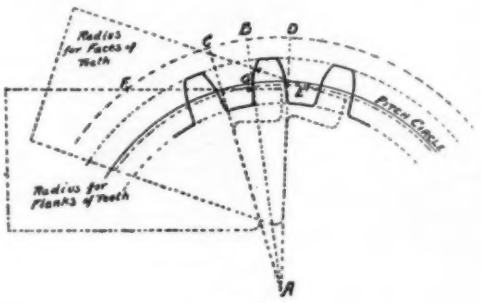


FIG. 6.

use of the odontograph is now required. First get the number of divisions given on the scale for the centre for the face of the tooth; for a wheel having fifteen teeth of $1\frac{3}{4}$-in. pitch the number will be found to be ten. Lay the odontograph on the drawing with the zero line touching the pitch circle and following the line D A. Mark point E ten divisions from the zero line, and on that side which specifies for faces of teeth, then with E as centre and E G as radius, describe an arc which represents that part of the curve on the outside of the pitch circle. To find the centre for that part of the curve which is inside of the pitch circle, the odontograph must be moved, keeping the point zero on the pitch circle but following C A. Referring to the scale, on that part which denotes for flanks of teeth, we find that for the wheel taken as an example, 86 is the number of divisions required. Thus by marking a point 86 divisions from zero, on that side which specifies for flanks of teeth, is given the centre of the curve, shown on Fig. 6 by F, and F G is the radius. Now, by marking temporary curves through F and E, with A as centre, and using F G and E G as the radii, all the teeth can be marked off.

The plain side of the odontograph can be used for proportions of teeth. The following table gives the proportions of teeth for spur wheels, also a constant, which, when multiplied by the number of teeth required with a given pitch, specifies the diameter of the pitch circle: —

TABLE III.—*Proportions of Teeth for Spur Wheels.*

Pitch in inches.	Constant for dia.	Height of teeth.		Thickness of teeth.
		Above pitch.	Below pitch.	
1	.3183	.344	.459	.450
1¼	.3979	.430	.570	.570
1½	.4775	.516	.689	.689
1¾	.5570	.602	.767	.809
2	.6366	.688	.865	.930
2¼	.7162	.774	.951	1.050
2½	.7958	.860	1.058	1.171
2¾	.8753	.946	1.153	1.292
3	.9549	1.032	1.248	1.414
3¼	1.0345	1.118	1.343	1.535
3½	1.1141	1.204	1.438	1.657
3¾	1.1936	1.290	1.532	1.778
4	1.2732	1.375	1.625	1.900

Another, and perhaps more practical, method for ascertaining the proportions of teeth is indicated by Fig. 7. Draw a horizontal line 4 in. long, divide this line into sixteen equal parts and draw vertical lines from each point. Divide the outside vertical line, which must be the same length as the base, into fifteen equal parts, and from points 1, 5, 6, 7, and 8 draw lines meeting at A, as in sketch.

All pitches are marked on the base and all sizes are to be taken from the base line. From the base line to the line drawn from 1 indicates the clearance of the teeth, from base to 5 the addendum or height above pitch circle, from base to 6 the dedendum or depth below pitch circle, from base to 7 the thickness of tooth on the pitch circle, and from base to 8 the width of space between teeth on the pitch circle. Whatever pitch may be required, the distances must be taken from that particular place on the scale in a perpendicular direction from the base.

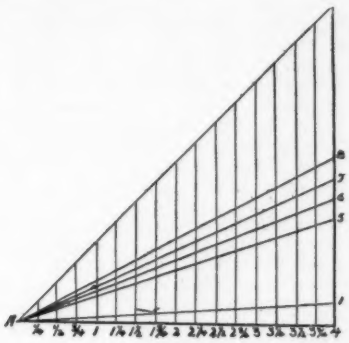


FIG. 7.

AMERICAN PIG-IRON PRODUCTION IN 1908.—The American Iron and Steel Association states that the production of pig-iron in the United States in 1908 was 15,936,018 tons (2,240 lbs.), against 25,781,361 tons in 1907, a decrease of 9,845,343 tons, or over 38.1 per cent. The following table gives the half-yearly production in the last four years:—

	1905. Tons.	1906. Tons.	1907. Tons.	1908. Tons.
First half ...	11,163,175	12,582,250	13,478,044	6,918,004
Second half...	11,829,205	12,724,941	12,303,317	9,018,014
Total ...	22,992,380	25,307,191	25,781,361	15,936,018

The production of Bessemer and low-phosphorus pig-iron in 1908 was 7,216,976 tons, against 13,231,620 tons in 1907, a decrease of 6,014,644 tons, or over 45.4 per cent. In the second half of 1908 the production was 3,828,485 tons, as compared with 3,388,491 tons in the first half, an increase of 439,994 tons. The production of low-phosphorus pig-iron alone in 1908 amounted to 130,616 tons, against 204,537 tons in 1907. The production of Bessemer and low-phosphorus pig-iron in 1908 was the smallest since 1897, when 5,795,584 tons were made.

The production of basic pig-iron in 1908, not including charcoal of basic quality, was 4,010,144 tons, against 5,375,219 tons in 1907, a decrease of 1,365,075 tons, or nearly 25.4 per cent. In the second half of 1908 the production amounted to 2,528,532 tons, against 1,481,612 tons in the first half, an increase of 1,046,920 tons. The total production in 1908 was slightly less than that of 1905, when 4,105,179 tons were made.

The production of spiegeleisen and ferro-manganese in 1908 was 152,018 tons, against 339,348 tons in 1907, a decrease of 187,330 tons. The production of ferro-manganese alone in 1908 was 40,642 tons, against 55,918 tons in 1907. Of spiegeleisen alone it was 111,376 tons, against 283,430 tons in 1907. In addition to the above several hundred tons of ferro-phosphorus were produced in the second half of 1908.

CANADIAN PIG-IRON PRODUCTION IN 1908.—Particulars, received direct from the makers, have been published by the American Iron and Steel Association relative to the production of all kinds of pig-iron in Canada during 1908. The total production amounted to 563,672 tons, as against 581,146 tons in 1907, a decrease of 17,474 tons, or about 3 per cent. In the first half of 1908 the production amounted to 307,074 tons, and in the second half to 256,598 tons, a decrease of 50,476 tons.

The production of pig-iron in Canada, in the last 15 years is given below, spiegeleisen and ferro-manganese being included:—

Years.	Tons.	Years.	Tons.	Years.	Tons.
1894	44,791	1899	94,077	1904	270,942
1895	37,829	1900	86,090	1905	468,003
1896	60,030	1901	244,976	1906	541,957
1897	53,796	1902	319,557	1907	581,146
1898	68,755	1903	265,418	1908	563,672

RUSSIAN PIG-IRON PRODUCTION.—The following are official statistics of the production of pig-iron and castings in Russia. The production in 1907 amounted to 2,820,604 metric tons, as compared with 2,691,606 tons in 1906, 2,713,674 tons in 1905, and 2,950,651 tons in 1904. The decrease in the four years was 130,047 tons. Castings made direct from the furnace are included.

BELGIAN PIG-IRON PRODUCTION.—The production of pig-iron in Belgium during last year comprised 127,630 tons of forge pig, 76,190 tons of foundry pig, and 1,002,620 tons of Bessemer and basic pig—a total of 1,206,440 tons, which compares with 1,427,640 tons in 1907.

The Importance of Industrial Education.

The Secretary of the American Foundrymen's Association has issued a note on the question of Industrial Education. "A study of the current literature," he says, "only emphasises the fact that any and all attempts of individuals or associations to establish schools for the training of our youth for vocational life, while by no means wasted, are simply so many drops of water in a very big bucket. It is necessary that this work be made part of the public school system of the country, that the curriculum be arranged accordingly, and primarily the teaching staff be trained to enter into the necessities of the case in a whole-hearted and effective way."

"The work of our Committee on Industrial Education is attracting much attention among prominent educators of the country. The Chairman, Mr. P. Kreuzpointner, of Altoona, is kept busy disseminating information concerning American and European needs and accomplishments, and one recent enquiry from the Superintendent of Schools of Seattle, Wash., elicited a long answer by our Chairman.

Extracts of the reply are here given.

"I take pleasure in answering your query as to whether the United States is likely to lose its industrial standing because of our unpreparedness for training those who are to enter industrial life.

"Being a product of Germany's (Munich's Industrial Schools as they existed fifty years ago when I was an apprentice, from 1856 to 1861), and having followed the development of European systems of industrial education ever since, knowing the intense pressure of their economic conditions, and knowing the drift of their industries approximately well, I answer your question in the words of prominent foreign engineers who visited this country and studied its industrial conditions. Their opinion seems to be that, unless we adopt a system of thoroughly training our industrial workers in a manner similar to their own, this country cannot keep up its present industrial pace for more than twenty years, because the education of the mass of the people—necessary to meet the ever-tightening economic conditions due to increase in density of population and decrease in quality, or quantity, of our resources, or both—is inadequate and inefficient.

"In 1904, the German Government sent a commission of six picked educators to study American educational facilities. They thoroughly investigated and reported that it will be many years before our industrial education will approach the effectiveness of theirs, if ever.

"In 1903, the Superintendent of Industrial Education of the Empire of Austria had some correspondence with me and among other things asked me my opinion as to the probable fate of Austria's small industries, which are the mainstay of that country, because of lack of resources to support extensive concentrated manufacturing, these small industries being hard pressed by the flooding of Austria's cities with American goods. I told him that if Austria could keep its small industries above water for twenty years, they would not be much troubled by American competition for two reasons: First, that so little attention was paid in this country to technical education in our schools, that when this necessity for technical and scientific training is grasped and attempted, the psychological condition of the present growing generation will be too far advanced. It will not be receptive for philosophical thinking. The mind of present and past generations will have run exclusively along mechanical lines and mathematics in the higher branches, and along lines of manual dexterity in our manual training and trade schools. Thus a new generation will have to be made receptive, psychologically, to absorb and develop, upon a national scale, the mental power of readily grasping the depth and breadth of technical education such as we need to bring us approximately to the standard of industrial education of our foremost foreign competitors. Second, because of the absence of this technical training and the wasteful habits of the people and its workmen, habits which are the inheritance of a time when the people believed, as many still believe, that our resources are inexhaustible and hence can be wasted with impunity. These wasteful habits and lack of technical knowledge necessary to make the best use of our remaining resources, cause them to diminish so rapidly that the next generation will have to exercise economy to keep enough for the growing home population, and little will be left to throw the products of our industries upon the markets of our competitors in competition with their home industries.

"To raise money for the establishment of a comprehensive system of public trade and industrial schools should not be so difficult for us if poor Belgium, Germany, and Austria can do it. The city of Munich, of 520,000 inhabitants, supports 48 trade schools and 12 manual training schools. If we had relatively as many as the little kingdom of Würtemberg, we ought to have 30,000 industrial schools, in proportion to population. Pennsylvania alone ought to have 1,000. The city of Hagen, Prussia, I am informed, are to expend for this year, 1908, 33 per cent. of the total taxation of the city for school purposes, and even that does not provide for this year's increase of population. . . . . I do not know what the city's budget was for 1907, but for 1908 it was three million marks (£150,000), and there were more than one million marks of that three million appropriated for schools. There were 600 girls in the domestic science school, and all the boys, of course, were obliged to go to some kind of industrial school until 17 years of age. No wonder the American Consul at Stuttgart, Würtemberg, complains that less and less is imported from the United States and more and more is exported to the United States. . . . . Summing up, then, the various points in answer to the question whether the United States is likely to lose its industrial standing because of the absence of systematic training of those who enter industrial life, the answer must be in the affirmative as long as we make no concerted and systematic effort as a nation to supply that training. The foundation of our phenomenally rapid industrial development and strength thus far has rested upon the immense wealth of our resources, and our free institutions and pioneer spirit of independence which fostered an individualism that rioted in our resources without thought of consequences.

"This question is becoming and has become a national issue, and this issue has to be met by an intelligent, liberally supported, and universally extended system of trade and industrial schools as a continuation of our elementary schools. So far as we ignore these economic changes, so far as we hesitate to recognise the educational necessities of the economic and industrial situation, so far as we refuse to make the necessary sacrifices for the industrial and technical training of the mass of our industrial workers; will the United States lose its industrial and, as a consequence, its political standing."

Yours, etc.,

PAUL KREUZPOINTNER.

The Tropenas Process for the Manufacture of Steel Castings in Small Quantities.*

By Arthur Simonson.

The fact that we are now able to procure, in many steel foundries, castings of good quality has resulted during the course of the past twenty years in a great transformation in construction in general, and in mechanical and metallurgical construction in particular. Heavy and massive pieces are made in the open-hearth furnace, and medium and small pieces in the converter. The open-hearth has played its important part in the development of the now extensive steel foundry business, but it is chiefly the small converter which has been the principal factor, on account of its more easy adaptation to all the details of miscellaneous manufacturing, its elasticity of production and its cost.

The Small Converter.

The converters generally used in the steel foundries have a charge capacity varying from 1 to 3 tons. The 2-ton converter has been the one most generally employed by the smaller, as well as larger, foundries. The 1-ton type, of which the cost of installation is little less than that of one of 2 tons capacity, has been little employed.

Since the invention of the Bessemer process, metallurgists have tried to adapt the principle to a type of converter of very small capacity, capable of producing steel castings which may be substituted on the one hand for ordinary cast iron, which is too fragile, and on the other hand for forgings, which are too costly.

It was Daniel Adamson, who, by his first researches in 1864 on lateral blowing with multiple tuyeres, opened the way, which was followed by numerous experimenters until 1884, the period of fixed converters, which was characterised by the work of James P. Witherow, William J. Clapp, and Thomas Griffiths, whose processes were used with more or less success for a considerable period. Then followed Charles Walrand, who applied the blast to one side of a movable converter, served by tuyeres of large section.

Robert, by adopting the Walrand principles, arrived at an approximate solution of the problem of the manufacture of mild steel castings direct from the converter, about 1880. The Robert converter met with an encouraging success. It permitted the manufacture of good steel, and was used in a number of foundries. The apparatus is movable, and is fitted with a small number of tuyeres of large section, arranged on one of the sides, which is straight. The compressed air acts through the metallic bath and near its surface, maintaining a gyratory movement which stirs the metal during the blow.

The Tropenas Converter.

In 1890, A. Tropenas established the new principle of blowing above the surface of a deep bath, to avoid the violent stirring considered by his predecessors as the indispensable condition of successful pneumatic operation.

The new Tropenas converter was much discussed by metallurgical writers, who did not attempt to disguise their disdain for a process in which one of the principles taught by them was so outrageously violated. The steel obtained by this process, which avoided the irregularities of the other methods, gave results of such a nature that the specified requirements of war and navy departments, railroad companies, and, consequently, the general industries were fully met. It was then installed by numerous establishments in different countries. The English, Russian, and Japanese Governments adopted it in their arsenals for the manufacture of special sections, and the United States Government installed it in five navy yards. It was, with few exceptions, the 2-ton converter which was adopted in these works.

The Small Converter Installation.

The cost of a 2-ton Tropenas installation, while much less than that of a Bessemer plant of the same capacity, represents an important investment, and many small foundries, to which a small steel department would be a most valuable addition, recoil from the expense. So the question has often been asked if it were not possible to bring out a type of converter which, instead of 2 tons, would be able to treat charges of 1,000 lbs. only, employing high-pressure blowers instead of the too costly blowing engines, with the power apparatus and accessories reduced and proportioned to the smaller charge. Since 1890, several engineers have constructed different types of converters with greatly reduced charges, but the results have given very little encouragement. It is very difficult to effect pneumatic refining conveniently when operating on a small mass of metal.

For refining a small charge it is necessary for the heat developed by the oxidation of the elements of the iron to raise the temperature of the bath rapidly to a high point, and that the temperature continually increase until the end of the operation. In the treatment of a small charge, the loss of heat, by comparison to the mass, is very high, and the least error or the smallest negligence on the part of the operator leads to an irregular and tumultuous blow, which produces a steel of bad quality, or too cold to be handled for the ordinary purposes of a steel foundry.

For a small converter to respond to the requirements of the small metallurgical industry it is necessary (1) that the steel obtained at the end of the blow be at a high temperature; that it be very fluid and that it retain that fluidity long enough to be distributed in small ladles and cast without haste or precipitation into the moulds which have been prepared; (2) that the mild steel obtained be of an entirely regular quality, and entirely deoxidised to produce sound pieces; (3) that the mechanical results obtained meet the conditions demanded by the Governments and railroad companies; (4) that the refining method be so simple that it can be comprehended in a few weeks by any intelligent workman; and (5) that the expense of the installation be not too high.

The numerous experiments made under the direction of Mr. Tropenas have permitted the realisation of this type of small converter, which solves in an absolute and complete manner the problem of the manufacture of steel castings in small quantities by the pneumatic process.

The small converter is not intended to supersede the 2-ton vessel which is now used when the amount of castings averages 100 tons per month or more, but

* Abstract of Paper read at the January, 1909, meeting of the Philadelphia Foundrymen's Association.

it may be a valuable addition to a cast iron or brass foundry, or for a construction firm which desires to be independent of the large steel foundries.

Equipment for the Tropenas Process.

The necessary equipment for this process is as follows:—

A cupola of special design, to melt the iron which is to be refined in the converter, and a special low-pressure blower to serve this cupola; a special converter in which is charged the iron previously melted in the cupola; a special high-pressure blower designed to produce the compressed air for refining the iron in the converter; a small crucible furnace in which is melted the final addition used to reduce the oxidation of the metallic bath; the necessary motors for driving the cupola and converter blowers and the accessory apparatus; cranes for handling the casting ladles and moulds; the materials and tools generally employed in all foundries, including flasks, drying stoves, annealing furnaces, moulding material, etc.

If a steel department is to be added to an iron foundry it should be separated entirely from the latter to avoid the mixture of the pig-iron and scrap.

The Metal Charged.

The iron used should be of the low phosphorus grade, the analysis limitations being as follows:—

	Per cent.
Carbon	3.80 to 4.50
Manganese	0.50 to 2.00
Silicon	1.50 to 3.00
Sulphur	Maximum 0.05
Phosphorus	Maximum 0.06

The carbon is not an element of prime importance and may vary between limits greater than those indicated above. The manganese may also vary between limits a little more than those stated, but it may result in the rapid wearing of the lining. The proportion of pig-iron entering into the charge for the cupola should be regulated by the quantity of scrap, gates, and heads which it is desired to utilise. As a general rule it is good practice to use all of the greater part of the scrap, gates, and heads which are produced in the steel foundry. The greater the proportion of scrap used, the greater must be the percentage of silicon in the pig-iron used.

Operation of the Converter.

The mixture of pig-iron and scrap is melted in the cupola, then tapped into a ladle which is lifted to the level of the mouth of the converter placed in the charging position, and its contents are poured into the vessel. The converter is then placed in the blowing position and the blast is admitted through the tuyeres. This operation is pursued up to the point of the complete transformation of the pig-iron into steel. It lasts about 15 to 20 minutes, according to the nature of the iron treated. The conduct of the operations is exceedingly simple and any intelligent workman can become a good operator in a short time.

Adding the time of blowing to the time of casting, the complete operation requires about 35 to 40 minutes. Counting five minutes for charging the converter, it is possible to complete the operation, or to produce about 1,000 lbs. of steel, every 45 minutes.

Cost of Production.

Taking as a basis the output given above, and supposing that a small steel foundry casts twice a week, the cost of the steel in the ladles would be as detailed below, which is verified by experience:—

Cost of Production.

	Dols.
10,400 pounds pig-iron at 21 dols. per ton...	10.10
5,200 pounds steel scrap at 15 dols. per ton	41.25
2,030 pounds coke for cupola at 4 dols. per ton	4.10
620 pounds limestone at 2.50 dols. per ton	0.80
One man and helper for cupola	4.00
7½ horsepower for cupola blower at five cents per kilowatt hour	2.80
1,100 pounds coke for converter and crucible	1.80
30 horsepower, three hours, for blower, five cents per kilowatt hour...	3.40
One man and helper on converter	4.50
793 pounds ferro-silicon at 28 dols. per ton	11.10
112 pounds ferro-manganese at 45 dols. per ton	2.52
Aluminium	0.70
Linings for cupola and converter	5.00
Crucibles	2.50
Power for elevator and tilting converter	1.10
General expenses of manufacturing	25.00
Total	210.67

The loss due to the melting in the cupola and the refining in the converter is from 15 to 18 per cent. In making the above calculation we have used 18 per cent. so as to be on the safe side; but the total loss, which varies according to the analysis of the pig-iron is, on the average, smaller. This, therefore, makes necessary in the calculations a total of 15,600 lbs. of the mixture of pig-iron and scrap for a net production of 6 tons of liquid steel, taken as the basis of the cost of production, the mixture melted in the cupola being composed of two-thirds pig-iron and one-third scrap.

Thus the price of the liquid steel ready to be cast into the moulds is in the neighbourhood of 1.60 cents per lb. This price does not include the general fixed charges of the enterprise, nor the interest on the capital invested.

The Resulting Steel.

The steel coming out of the converter being very hot and fluid, it is possible to cast pieces of very small size and extremely light weight. If the moulds are well prepared and the sand of proper quality, the castings produced are clean and have a good exterior appearance.

The greater portion of the castings are made of soft steel, which is almost exclusively specified by engineers. The test pieces tested by different customers at the foundry where two of these small converters are in operation, have given the following results on the usual soft grade of machine castings:—

Quality of Steel.

Test pieces.	Tensile strength per square inch, pounds.	Elongation, inches.	Reduction of area, per cent.	Remarks.
A 17	61,520	19.40	43.70	Fibrous
A 19	62,830	17.09	39.20	Granular, part fibrous
A 20	65,455	18.49	47.20	Fibrous
A 21	64,436	16.95	33.60	,,
A 23	62,713	17.48	35.50	Granular, part fibrous
A 25	65,294	20.14	44.20	Fibrous
B 110	71,359	21.03	45.60	Fibrous, granular
B 112	75,572	20.41	39.14	,, ,,
B 115	74,617	22.17	40.26	,, ,,
B 117	72,9,2	23.45	35.61	,, ,,
B 120	77,733	19.90	34.80	,, ,,
B 121	77,049	19.85	36.56	,, ,,

This cast steel forges like mild rolled steel without requiring more than ordinary precautions, and it welds as well in a forge fire. This feature permits the casting of complicated pieces in parts which are afterwards welded together.

Compared to an open-hearth furnace of small capacity this converter has the advantage of being much more elastic, and it accommodates itself to intermittent use. When the converter is stopped all consumption of power and fuel ceases, but in the case of the open-hearth one is obliged to keep up the fire after melting. Also, the steel produced is hotter and more fluid than that produced in the open-hearth.

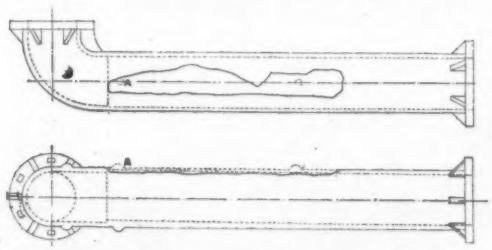
A Defective Cast-iron Steam Pipe.

The official report of the preliminary inquiry concerning an explosion which occurred on November 16, 1908, at the new 10-in. tandem rolling mill of the Wigan Coal and Iron Company, Ince, near Wigan, has just been issued.

The explosion occurred from a steam pipe, and as a result two men were injured. The pipe, which was made of cast iron, was 10 in. in diameter internally, and 11¾ in. in diameter outside, having a short bend at one end, the distance from the centre line of the pipe to the face of the flange being 12 in.; and the length of the pipe from the centre of the bend 7 ft. 1 in. The flanges at the ends were 17¼ in. in diameter, flat, machine faced, and 1½ in. thick. Each of the joints was made with an asbestos ring placed within the bolt circle.

The pipe was made by the Wigan Coal and Iron Company, at their Sawmills foundry, Wigan, in September, 1908, and no repairs had been done to it. It was inspected before leaving the foundry by the foreman moulder, and was again inspected and tested

VIEW SHOWING BOTTOM SIDE OF PIPE.



VIEW SHOWING THE POSITION IN WHICH PIPE WAS MOULDED.
FIG. 1.

by hydraulic pressure to 200 lbs. per square inch. Again, just previous to being erected in position, it was examined by the engineer to the Company.

In the explosion a portion, about 4 ft. long and having a width varying from 1½ in. to 5¾ in., was blown from the bottom of the straight part of the pipe, the pieces shattering the windows of the engine house immediately below, thus giving free access for the steam to escape from the boilers into the engine house.

The report states that the explosion was due to the inherent weakness of the casting which, although intended to be of a uniform thickness of ¾ in., was only $\frac{5}{32}$ in. to ½ in. thick at the part which gave way. This was due to the core in the straight part of the pipe having floated during the process of casting. The chaplets to retain the core in position, being weak, had failed to hold the core down whilst the metal was being poured into the mould.

The part of the works in which the explosion occurred is an entirely new wing, the engine for driving the mill being of the horizontal, tandem, compound condensing type, having two cylinders 20 and 36 in. in diameter respectively by 42 in. stroke, developing 600 indicated horse-power at 90 revolutions per minute. Steam is supplied from three Galloway boilers placed at some distance from the engine house. A steam drum passes over these boilers, from which the steam is led to the engines by a range of cast-iron piping, 10 in. in internal diameter, of which the pipe which failed formed a part. The engine had been running at various intervals for about two weeks previous to the explosion. No priming of the boilers had ever occurred, and the pipes were efficiently drained. Between the boilers and the engine house the pipes were in the open air, and were not covered with any insulating material. On the day of the explosion the engines were started about 9 a.m., and after being stopped for about one hour for the purpose of cleaning down, were running almost continuously until about 2.30 p.m., when without any warning the explosion occurred.

Moulding the Pipe.

Continuing, the report states that it is evident that the bottom side of the pipe which failed had been the top side when in the mould, and that the core had been made in two parts, the straight portion being separate from the bent part. The latter had been held securely in position by the core print and an upper and a lower chaplet; but the straight portion of the core was secured by two chaplets about

FIG. 2.—ENLARGED SECTION, SHOWING CHAPLET A. (FIG. 1.)

3 ft. apart on the upper side and one on the lower side, as shown in the illustration (Fig. 1). It would seem that the chaplets alone were insufficient to withstand the floating power of the core, and had given way, allowing the core to rise, and thus leave the metal only $\frac{5}{32}$ in. thick tapering to ½ in. thick at the part which gave way.

The work in the foundry is under the personal supervision of the foreman, who is a skilled moulder. He had seen the core for the pipe put into position before closing the mould, and considered at the time that it was efficiently constructed, and that the chaplets were sufficient in size and number for the size of the core. The pipe was cleaned and sounded before leaving the foundry and was believed to be a successful casting. After the flanges were machined the pipe was tested by hydraulic pressure to 200 lbs. per square inch, and then erected in position, no one through whose hands it had passed having noticed that it was in any way defective. The pipe, however, failed under ordinary working conditions, being unable to withstand the steam pressure of 115 lbs. per square inch when subjected to vibration and the movements due to the varying temperature.

The report concludes with a remark by the Engineer Surveyor-in-Chief, who observes that although the defect might, no doubt, have been discovered had the casting been examined and carefully measured before it left the foundry, the case is one of many which serve to show the unreliability of steam pipes made of cast iron, and the unsuitability of that material for their construction.

The Keeping of Foundry Accounts.

By W. E. Cowens.

The study of costs is not only interesting, but will repay any labour bestowed upon it.

Some return must be allowed for initial outlay, and a proper account of this should be kept in the plant book. There should be separate accounts for land, buildings, and for each machine, and in order that they may be regularly filled up separate orders should be entered for each. All repairs should be posted to these orders, and regularly transferred from the repairs book to the plant book, so that everything spent on buildings or machines can be readily traced. If a new machine is installed a new order should be

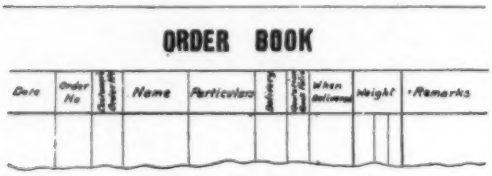


FIG. 1.—ORDER BOOK.

entered for it. If an old machine is scrapped it should be struck out of the plant book, the date attached, and its value as scrap accounted for.

Interests on Outlay.—If the foundry belongs to a private firm or a limited company having ordinary shares only, this may be allowed for by the amount the principals add to each estimate for profit. They run the risk of the market and may earn a good or bad dividend according to the output obtained. If the company, on the other hand, have debenture or preference shares—the interest on which must be regularly paid—it is better to consider this interest as a standing charge, and allow for it under the item of establishment charges.

Depreciation.—It is necessary to write off each year

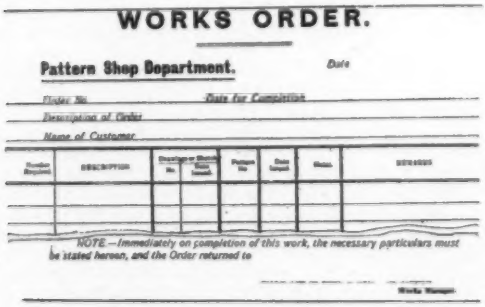

WORKS ORDER.
Pattern Shop Department.
Date
Order No.
Date for Completion
Description of Order
Name of Customer
DESCRIPTION
NOTE.—Immediately on completion of this work, the necessary particulars must be stated hereon, and the Order returned to

FIG. 2.—SHOP ORDER FORM.

a certain fixed percentage for depreciation of building and machinery, so that by the time a machine is worn out its value in the plant book shall be reduced to scrap. The amount written off should be for buildings 3 per cent. and for machines, engines, and boilers 5 per cent.

Repairs.—These should be charged against revenue, as they are necessary in order to keep the plant efficient.

Bank Interest.—If an overdraft is obtained for any reason interest will have to be paid to the bank, and will be an item in establishment charges.

Insurance.—Fire insurance and insurance against Workmen's Compensation and Employers' Liability Acts will also form an item in establishment charges.

How to Deal with the Items.

Having obtained our equipment we are in a position to commence work. In an ordinary jobbing

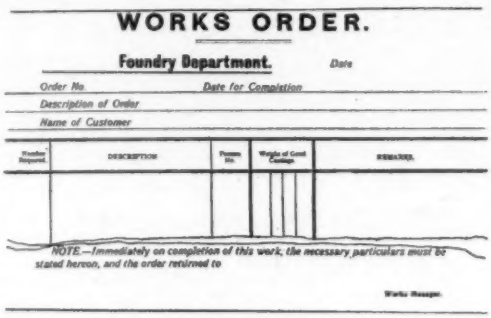


FIG. 3.—SHOP ORDER FORM.

foundry we deal with three classes of work, viz., dry sand, green sand, and loam castings. The cost of any of these will be made up of the following items:—Materials used in manufacture, labour spent in manufacture, cupola cost and special loam charges, shop charges, and establishment charges.

Material.—The material used is of a varied nature; it comprises pig-iron of various kinds, scrap, hard coke, gas cinders, coal, limestone firebricks, fireclay and ganister, plumbago, blacking, coal dust, loam, sand, yellow clay, core ropes, core irons, chaplets, cupola tools, tools for workmen, such as sieves, bellows, pails, shovels, barrows, chains, cramps, etc., etc.

Contracts should be made for all materials, and as they are received the invoices should be carefully

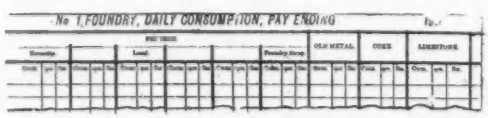


FIG. 4.—CUPOLA SHEET.

checked and the prices noted. The cost of iron used will be obtained from the cupola sheet. Chaplets should come through the stores supply book and be charged direct to the order number. All other material and tools should be debited against the foundry, and either come through in shop charges or cupola cost.

Labour.—The labour will consist of moulders, coremakers, apprentices, cleaners, fitters, and labourers, and should be charged direct to order numbers. These items should be taken out of the time book by the time office and entered on a time abstract sheet, which should be passed into the cost office.

Cupola Costs.—Cupola costs consist of men's time charging and tapping, unloading pig-iron and scrap

and breaking it up ready for use, repairs to cupola including relining when required, cleaning and daubing ladles, coke and wood for the bed, coke used in melting, cost of power for the blower and hoist, blacking for the ladles, water, and the loss on re-melting. These costs should be made up every half-year. Separate order numbers should be entered for men's time tapping and charging, unloading, and breaking up pig and scrap, repairs to cupolas, hoist and ladles. This time is all abstracted by the time office and entered on a time abstract sheet which is sent to the cost office. The total cost of repairs is obtained from the repairs book which includes all material used. All other material, such as pig, scrap, coke, and lime-stone, is obtained from the stores supply book or from the cupola sheets. The cost of power, water and lighting, is apportioned from the total cost. The items forming the cupola costs, if totalled and divided by the total number of tons melted in the half-year, would give the cost of the cupola charge per ton. This charge will be found to vary with the quantity and nature of the output. The works' manager must fix the amount of the costs, and estimates should be based upon each half-year's results.

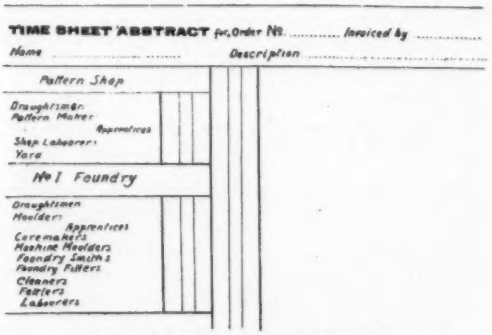


FIG. 5.—TIME ABSTRACT SHEET.

For loam castings the cost of the stoves, labour on the loam floor, cranage, and the cost of the milled loam are additional items peculiar to this class of casting; an additional cost of 10s. per ton is added to cover this.

Shop Charges.—The shop charges consist of management expenses, fireman, clerk, foundry-smith, box fitter, craneman, slingers, and stove-man; the time for these cannot be charged to job orders. Power for the cranes, and other machinery, lighting, water, repairs, repairs and preparation of boxes, hauling, and removal of rubbish, etc., also come under this heading. An entry should be made in both materials and wages cost books for "indirect expenses," and these should be drawn together and totalled each half-year. They are either dealt with by charging so much per ton on the output of finished castings, or at a percentage upon the direct labour.

Establishment Charges.—These consist of rates, rent, taxes, salaries of staff not accounted for under shop charges, interest, depreciation, insurance, advertising, agents expenses, and directors' fees and expenses. These charges pass through the books in the same way as the other "indirect charges," except that they are usually dealt with by the secretary through the private ledger, who works out the percentage and gives it to the cost-clerk each half-year. They will generally be found to average from 25 to 35 per cent. upon production wages.

Treatment of an Order.

Having now followed the method adopted for recording the various items in the cost, we will follow a customer's order from its receipt to the completion of its cost. The order when received is entered in the order book, and shop-order forms are issued to the pattern shop and foundry. It is always advisable to issue an order to the pattern shop ever if the customer provides the patterns, as the pattern maker is held responsible for the receipt and safe custody of all patterns received. The shop orders all pass the works manager's office, who signs and issues them to the shop foreman. As soon as the order is completed the form is returned to the works manager, who sees that all requisite information has been filled in, adds any remarks required to guide the cost-clerk, and returns it to the costs office.

In making out the cost the cost-clerk refers to the foundry day-book for the weights and for the number of castings made. The time abstract sheet will give all the labour expended upon it. The cupola sheet will give the cost of the metal used at per ton. The cupola melting charges, special loam charges, and shop and establishment charges are added from the particulars which have already

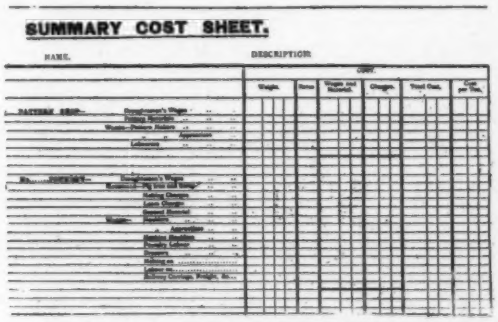


FIG. 6.—SUMMARY COST SHEET.

been given him, and the summary cost is completed and placed before the manager showing whether a profit or loss has been made.

Where large castings are concerned, a progress wages cost should be made up each week and sent to the works manager, so that he may see the amount spent up to date and compare it with the progress of the work. A cupola summary sheet should also be sent by the cost-clerk to the works manager each week; this shows the amount of metal melted, its cost, the coke used per ton of metal, the percentage of left metal, and the labour cost per ton both for skilled and unskilled labour. These are occasionally made out in the form of diagrams, and a red line is drawn across showing the basis output at which the charges have been completed.

Faulty castings require careful watching. In larger castings a new order should be entered for a replace. For small castings this is not practicable, but the daily returns taken by the job-order clerk should show every casting made and the cost-clerk can then obtain the record on the completion of each order. The record for faulty work should always be sent to the works manager with the workman's name and number, and the cause of the defect should be ascertained.

The illustrations show the forms used on this system. They will explain themselves.

The writer will be pleased to reply to any queries from readers who require further elucidation of the system.

Making Composition Pattern Plates.

In fitting patterns to a moulding machine where complete pattern plates are to be used it is necessary to provide both cope and drag plates. In many cases a gate or master pattern has been provided from which these plates must be made.

The Arcade Manufacturing Company, Freeport, Ill., U.S.A., has developed a system of composition plates to be used in connection with its machines. Plates of this kind and of large size may be used for floor or bench work. The process is described by "Castings," and is as follows:—

A good mould is made from the gate of the patterns and a duplicate gate cast in white metal, using a metal having as small a shrinkage as possible. To insure proper setting of the parts in the mould, and to avoid the danger of assembling the finished plates incorrectly, it is necessary to have each of the separate castings marked so that the mark will reproduce itself on the duplicate white metal pattern. This may be done by notches or prick punch marks.

After the duplicate patterns have been made the master pattern is again placed on an iron surface plate. The patterns must be securely blocked so that they will not rock. This may be accomplished by using paper or pasteboard liners. The height to the parting

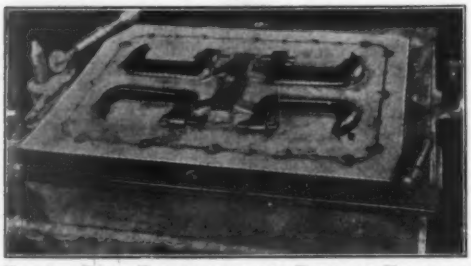


FIG. 1.—DRAG RAMMED UP AND PARTING FINISHED.

line from the plate is measured, and a pair of wooden strips of corresponding thickness placed at the ends of the plate.

The drag portion of the flask is then set in position, and a good hard mould rammed up, using new sand. The flask is rolled over and the surplus sand cut away to the parting, great care being taken to finish the parting carefully.

The finished parting for the drag is seen in Fig. 1. Particular attention is called to the tracing or groove shown around the outside of the patterns. The groove is made by a tracing wheel, while the round indentations are made by a rivet head. The object of this work is to form impressions on one plate which will correspond with projections on the other and thus will fit accurately both in the plates and the finished mould. This insures accurate fitting of the mould after the snap flask is removed, and thus prevents shifts when the moulder places his work on the floor.

Setting Flask and Frame.

Another point of importance is that some designating marks should be used to keep the flask and frame always in the same position so as to avoid any possibility of placing the cope on the drag wrong end to. To accomplish this end, the flasks are all marked with the letter "F" on one end which corresponds to the front position in their moulding machines.

This marked end of the flask or plate is always kept at the right of the operator during the entire process of making the composition pattern plates. A notch filed in one end of the flask and in the corresponding end of the plates will accomplish the same purpose.

Cope.

After a drag has been rammed up, as is shown in Fig. 1, the cope portion of the flask is placed upon it, rammed up and lifted off.

A sprue pin is set over the centre of the gate when ramming the cope and the pattern rapped through the hole left after the pin is withdrawn. After the pattern has been rapped the hole left by the sprue pin is filled with sand and rammed up.

When the cope has been lifted from the drag it is placed on its back and the duplicate white metal patterns placed in it as shown.

Separation of Patterns and Gate.

The patterns are cut away from the gate, the objects being to correct any slight shrinkage that there might be in the gate of patterns, and to enable the moulder to place the parts accurately—a task which could not be easily accomplished by handling the

FIG. 2.—THE COMPOSITION FRAMES.

entire gate at one time because the white metal might be slightly bent.

When making gates for large castings by this process, the duplicate castings are sometimes sawed apart in several places and the parts adjusted to the outer dimensions of the mould so as to take up any shrinkage. These saw cuts are afterwards soldered up when the patterns have been fastened in the composition plate.

Only one side of the white metal patterns is to be finished, as one side will be embedded in the composition plate, and hence will not require finishing. The finished side must be placed down in the mould

Pouring the Plates.

The sand moulds with their patterns in place are now ready to have the composition plates poured on top of them. To successfully accomplish this the composition plate frames depicted in Fig. 2 are placed upon the moulds. These frames are always given designating marks so as to keep them right end to.

It is to be noted that there are five holes in the back plate of each composition frame. These serve for pouring the composition through and also act as risers.

The mixture used for pouring these plates consists of two parts of Portland cement, one part plaster of Paris, and one part sharp sand. This combination

must be made dry and the ingredients thoroughly mixed. To accomplish this it is best to do the mixing in two boxes and to pour the material from one box to the other through a half-inch riddle. This operation should be repeated eight or ten times to thoroughly mix the material. A sufficient amount of water is then taken in a pail and the mixture stirred into it. As soon as the wetting of the mixture begins it is necessary to work rapidly until the plate is completed. The mixture should be very wet on account of the fact that the composition is to be poured against the sand, and as the sand will absorb the moisture from the composition, if the mixture is not wet enough, the plate will check. The mixture should be the consistency of clay wash.

The plate should be poured from the two opposite corners, the other three openings acting as risers. The material should be fed into all five of the risers by adding a little as it settles, and it also should be fed down with a stick—or better still, the finger—until the hardened material rises above the level of the back of the plate. If the plaster of Paris and cement are fresh the mixture should set fairly hard in from 10 to 20 minutes.

As soon as the composition is set, as indicated by the portions which project in the risers, the risers are removed and the extra composition cleaned off level with the back of the plate. The plate with the flask attached is then rolled over and the flask lifted off. Considerable sand will adhere to the face of the composition, and this may be removed by placing the plate at an angle of 45 degrees and washing off the sand with a soft brush and water.

The cope plate is made in the same way.

It will be noted that while the white metal patterns were put into the sand mould corresponding to the cope, in the composition plate they are in the part corresponding to the drag and hence will make the cope of the finished mould.

In like manner the original gate of patterns was placed in the drag portion of the master mould and from there transferred into the cope portion of the composition plate so that they will be used for making the drag portion of the finished mould.

The patterns are secured on the plates by drilling holes through the patterns, the composition backing and the iron plate behind the composition. The holes in the patterns are then countersunk and stove bolts used for bolting the patterns in place. The heads of the stove bolts in the patterns are soldered over. It is always wise to solder the nuts on the ends of the bolts on the back of the plate so as to prevent their getting loose, especially if the plate is to be used in connection with a vibrator.

When the metal pattern-maker is doing this work he always solders up any cuts which have been made between the gates of the patterns and the different parts or the patterns of the white metal set.

The plates are then prepared for use in the foundry by giving the surface of the composition a coat of boiled linseed oil. It is heated with a gasoline torch for about ten minutes, which causes the oil to be absorbed by the plate. When the plate has absorbed as much oil as it will, whatever remains on the surface is cleaned off with benzine.

Plates of this kind are much more permanent than the ordinary matches made from clay and litharge, and as the patterns are secured firmly to the iron plates back of the composition, the whole makes a very permanent structure.

There are a few precautions which must be followed in this work. In the first place, all the materials used must be fresh. The stock of plaster of Paris and cement must be kept in a dry place, preferably in a covered box which will not expose the material to the air.

When the mixture is made, that portion of it which is not used should be thrown away. By the time the moulder would be ready to use it for the next plate it would have absorbed moisture enough from the air to render it unfit for use.

When the material sets slowly, it is evidence that either the cement or the plaster is not good. The plaster causes the mixture to set quickly, while the cement gives it great strength.

Plenty of water may be added to the mixture before pouring for the excess will be absorbed by the sand or rise to the surface through the riser, and overflow. It is better to have the mixture too wet than too dry.

MR. E. J. LECOT has been appointed one of the representatives of F. Reddaway & Company, Limited, of Pendleton, Manchester, the well-known engineers and manufacturers of "Camel Hair" belting, etc.

MESSRS. J. S. WALFORD & SONS, brass founders, of the Paragon Works, Hampton Street, Birmingham, have appointed Messrs. W. A. Perkins & Company, 10, Camomile Street, London, E.C., as their London agents.

MESSRS. R. LUND, J. H. ANNEVELD, and F. C. POLDEN, electrical and general engineers, Queen Victoria Street, E.C., trading under the style of Lund Bros., & Co., have dissolved partnership, so far as regards Mr. J. H. Anneveld.

MR. ERNEST WILKES, Pelsall Foundry, near Walsall, has purchased a site for new works, adjoining and having sidings at Pelsall Station, on the South Staffordshire main line. The erection of the new works has not yet been commenced, but they will be put up on modern lines, and the Pelsall Foundry will eventually be closed.

CLARKE, CHAPMAN & COMPANY, LIMITED, of Gateshead, have opened an office at 40, King's Chambers, Angel Street, Sheffield, and Mr. Alfred Atkinson, who is in charge of the district, has secured the services of Mr. Frederick G. Hawksley, who was for some years director and works manager of Hawksley, Wild & Company, Limited, of Sheffield.

THE INSHAW SEAMLESS IRON AND STEEL TUBES. LIMITED, Wishaw, N.B., have appointed the Midland Agencies, Limited, their sole agents for the Midlands. The Midland Agencies' Birmingham Depôt is at 42, Summer Row, where they have extensive warehouse accommodation, and propose holding a large stock of all standard sizes of tubes.

THE CAMBRIDGE SCIENTIFIC INSTRUMENT COMPANY, LIMITED, Chesterton Road, Cambridge, have been appointed sole manufacturers and agents in Great Britain and the Colonies for the burners and furnaces designed by M. Méker. In one of these furnaces employing M. Méker's burner, in which exceedingly high temperatures can be obtained quickly, it is possible to melt copper (1084 degrees C.) without the aid of an air blast.

THE GLACIER ANTI-FRICTION METAL COMPANY, LIMITED, of Glacier Building, 112A, Queen Victoria Street, London, E.C., notify us that owing to the steady increase in their business they have erected new works near Willesden Junction, and have equipped same with thoroughly modern furnaces, and appliances, for the accurate and economical manufacture of white metal alloys, and are now manufacturing in addition to their Glacier metal, all grades of Babbitts metal—white bronze—and white alloys to specification. The company's office address remains as before.

Training Workmen in Habits of Industry and Co-operation.*

By H. L. Gantt.

The widespread interest in the training of workmen which has been so marked for several years is due to the evident need for better methods of training than those now generally in vogue. The one point in which these methods as a class seem to be lacking is that they do not lay enough stress on the fact that workmen must have industry as well as knowledge and skill. Habits of industry are far more valuable than any kind of knowledge or skill, for with such habits as a basis, the problem of acquiring knowledge and skill is much simplified.

In a paper entitled "A Bonus System of Rewarding Labour," read before this Society in December, 1901, there was described a system of task work with a bonus which had recently been introduced by the writer into the large machine shop of the Bethlehem Steel Company. Under this system each man has his work assigned to him in the form of a task to be done by a prescribed method with definite appliances and to be completed within a certain time. The task setter, or his assistant, acts as an instructor to teach the workmen to do the work in the manner and time specified. If the work is done within the time allowed by the expert, and is up to the standard for quality, the workman receives extra compensation in addition to his day's pay. If it is not done in the time set, or is not up to the standard for quality, the workman receives his day's pay only.

This system, in connection with the other work of Mr. F. W. Taylor, so greatly increased the output and reduced the cost of the work in the large machine shop of the Bethlehem Steel Company that for the past seven years the writer has given a large portion of his time to the development of its possibilities. The results have far exceeded his expectations.

The fact, so repeatedly emphasised by Mr. Taylor, that tasks should be set only as the result of a scientific investigation, has proved of an educational value hardly to be over-estimated, for the scientific investigation of a process that has been developed without the assistance of science almost always reveals inconsistencies which it is possible to eliminate, thus perfecting the process and at the same time reducing its cost. It is this scientific investigation that points to improvement in methods and educates owners and managers; but the average workman is interested only in his daily wage and has no special desire to learn improved methods. The results of our investigations are of little practical value, therefore, unless we can first teach our workmen how to use them, and then can induce them to do as they are taught.

Practical Application.

For this purpose an instructor, a task and a bonus have been found most useful. Unskilled workmen, who under these conditions have become skilled in one kind of work, readily learn another, and soon begin to realise that they can, in a measure at least, make up for their loss in not having learned a trade. As they become more skilled, they form better habits of work, lose less time, and become more reliable. Their health improves, and the improvement in their general appearance is very marked. The Task and Bonus method of training not only furnishes the workman with the required knowledge, but by offering an inducement to utilise that knowledge properly, trains him in proper habits of work.

Habits of Work.

In all work both quantity and quality must be considered, and our task method demands a maximum quantity, all of which must be up to the standard for quality. Workmen trained under this method acquire the habit of doing a large amount of work well, and disprove the oft-repeated fallacy that good work must be done slowly. As a matter of fact, our quickest workers almost always do the best work when following instructions.

Habits of work in a mechanic are comparable with habits of thought in an engineer, and our industrial schools should make proper habits of work the basis on which to build their training in manual dexterity. As the writer sees it, one of the most valuable assets that the graduate of a technical college or an industrial school can have is the habit of doing promptly and to the best of his ability the work set before him. This habit is one of the first results of the Task and Bonus system, for it is a noticeable fact that task workers form habits of industry which they maintain even when on day work with no bonus in sight.

In all schemes for technical or industrial education or training that the writer has seen, emphasis has been laid on the importance of knowing how. The writer wishes to add that ability and willingness to do are of at least equal importance. Many skilled workmen make their skill an excuse for slow work, and unless when they are taught how to do they are also taught to do efficiently, they never attain the success that should be theirs.

Under our task system the workman is taught how and trained to do at the same time. Knowing and doing are thus closely associated in his mind, and it is our experience that the habit of doing efficiently what is laid out for him becomes so fixed that he performs without hesitation tasks at which a man not trained to follow instructions would absolutely fail. Workers who have been unable to perform their tasks in the time set have frequently asked to have an instructor stand by them with a stop-watch to time the detail operations and show them just wherein they failed, with the result that they soon learned to earn their bonus regularly.

The first essential for a workman to become successful under our task system is to obey orders, and having acquired this habit he soon finds out that a skilled investigator can learn more about doing a piece of work than he knows "off hand." Having satisfied himself on this point, he goes to work at the tasks set him with the determination to earn his bonus, with the result, if he has the natural ability, that he soon becomes a rapid and skilful workman. Learning to obey orders is often the hardest part of the workman's task, for a large percentage of men seem so constituted as to be apparently unable to do as they are told. As a rule, however, this is a feature of a certain stage of their development only, which under proper conditions they overcome at a later date.

* Abstract of Paper presented at the New York Meeting (December 1 to 4, 1903) of The American Society of Mechanical Engineers, and printed in the "Journal" of the Society.

"Bosses" as Servants and Teachers.

In a shop operated on this system, where each workman has his task, one man whom we term a "gang boss" usually tends a group of workmen, supplying them with work and appliances and removing the work when finished. Such a man is paid a bonus for each workman who earns a bonus, and an extra bonus if all his group earn their bonuses. The result is that so long as the workmen perform their tasks, though nominally their boss he is really their servant, and becomes the boss only when a workman fails to perform his task. The loss of money to the gang boss in case a workman fails to earn his bonus is such that he constantly has his eye on the poor workman and helps him all he can. If, however, he finds that the workman is incapable of being taught, he uses his influence to have a better man put in his place.

In starting a shop on task work, an instructor who is capable of teaching each workman how to perform his task must be constantly on hand, and must as a rule teach one workman at a time. This instructor may be the man who has investigated the work and set the task, or he may simply be an instructor capable of following out the work of such an investigator, but he must be readily available as long as any of the workmen need his services, for we make it a rule not to ask a man to do anything in a certain manner and time unless we are prepared to show him how to do it as we specify.

Task Setting.

A task must always be set for performing a definite operation in a specific manner, a minimum time being set for its accomplishment. As compensation, the workman is paid for the time set plus a percentage (usually 20 to 50) of that time, provided the work is done in the time allowed or less. If the time taken is more than the time allowed, the workman gets his day's pay only. The fact that in setting the task the manner of performing the operation is specified enables us to set another task for the same operation if we develop a better or quicker method.

If after having performed his task a workman wishes to suggest a quicker or better method for doing the same work, he is given an opportunity, if possible, to demonstrate his method. If the suggested method really proves to be quicker or better, it is adopted as the standard, and the workman is given a suitable reward. No workman, however, is allowed to make suggestions until he has first done the work in the manner and time specified.

Inasmuch as, after a satisfactory method has been established, a large proportion of the work of the task setter is the study of the time in which operations can be performed, he is popularly known as the "Time Study" man. This term has lead to a misconception of his duties and has caused many honest people to claim that they were putting in our methods when they have put a stop watch in the hands of a bright clerk and told him to find out how quickly the best men were doing certain work. Unquestionably they have in many cases been able to set more accurate piece rates by this method than they had been able to set by the older methods, but they are still far from our ideal, in which the best expert available investigates the work, standardises the appliances and methods, and sets a task that involves utilising them to their very best efficiency.

Standardisation.

All work, and all knowledge, for that matter, may be divided into two classes: Expert and Standard. Expert knowledge may be described as that which has not been reduced to writing in such a manner as to be generally available, or exists only in the minds of a few. By analogy, expert work is work the methods of doing which either are known only to a few, or have not been so clearly described as to enable a man familiar with that class of work to understand them. On the other hand, standard methods are those that are generally used, or have been so clearly described and proved that a man familiar with that class of work can understand them and safely employ them.

The largest problem of our expert is to standardise expert methods and knowledge. When a method has been standardised, a task may be set, and by means of an instructor and a bonus a method of maintaining that standard permanently may be established. With increasing efficiency on the part of the workman the standard always has a tendency to become higher.

We have here the workman and the foreman using their efforts to maintain standards, for both fail to obtain a bonus if the standard is not maintained. This is so different from the case in which the standard is maintained only by the man in authority that there can be no comparison. From workmen trained under these methods, we get a good supply of instructors and foremen, and occasionally an investigator. From our investigators, who standardise our methods and appliances, we get our superintendents, and our system of management thus becomes self-perpetuating.

Obstacles.

Among the obstacles to the introduction of this system is the fact that it forces everybody to do his duty. Many people in authority want a system that will force everybody else to do his duty, but will allow them to do as they please. The Task and Bonus system when carried out properly is no respecter of persons, and the man who wishes to force the workman to do his task properly must see that the task is properly set and that proper means are available for doing it. It is not only the workman's privilege, but his duty, to report whatever interferes with him earning his bonus, and the loss of bonus soon educates him to perform this duty no matter how disagreeable it is at first. We investigate every loss of bonus, and place the blame where it belongs. Sometimes we find it belongs pretty high up, for the man who has neglected his duty under one system of management is pretty apt to neglect it at first under another. He must either learn to perform his duty or yield his place, for the pressure from those who lose money by his neglect or incompetence is continuous and insistent.

Day Work and Piece Work.

As used by the writer, the Task and Bonus system of pay is really a combination of the best features of both day and piece-work. The workman is assured his day rate while being taught to perform his task, and as the bonus for its accomplishment is a percentage of the time allowed, the compensation when the task has been performed is a fixed quantity, and is thus really the equivalent of a piece rate. Our method of payment then is piece-work for the skilled, and day-work for the unskilled, it being remembered that if there is only work enough for a few, it will always be given to the skilled. This acts as a powerful stimulus to the unskilled, and all who have any ambition try to get into the bonus class. This cannot be too clearly borne in mind, for we have here all the advantages of day-work combined with those of piece-work without the disadvantage of either, for the day-worker who has no ambition to become a bonus-worker usually of his own accord seeks work elsewhere, and our working force soon becomes composed of bonus-workers, and day-workers who are trying to become bonus-workers.

Co-operation.

When 25 per cent. of the workers in a plant are bonus-workers, they, with those who are striving to get into their class, control the sentiment, and a strong spirit of co-operation develops. This spirit of co-operation in living up to the standards set by the experts, which is the only way a bonus can be earned, benefits the employer by the production of more work, better work, and cheaper work. It benefits the workmen by giving them better wages, increased skill, better habits of work, and more pleasure and pride in their work.

The fact that we get better work, as well as quicker work, seems inconceivable to some. The reasons are:—(*a*) Careful inspection, for no bonus is paid unless the work is up to the standard; (*b*) work done by a prescribed method, and always in the same way; (*c*) attention needed to do high-speed work, which keeps the mind of the worker on what he is doing and soon results in exceptional skill.

The development of skilled workmen by this method is sure and rapid, and wherever the method has been properly established, the problem of securing satisfactory help has been solved. During the past few years, while there has been so much talk about the "growing inefficiency of labour" the writer has repeatedly proved the value of this method in increasing its efficiency, and the fact that the system works automatically, when once thoroughly established, puts the possibility of training their own workmen within the reach of all manufacturers. The fact that few plants only have established methods of training workmen does not necessarily mean that the managers are satisfied with that condition, but rather that they know of no training system that can be satisfactorily operated in their plants, and as questions are sure to be asked about the method of introducing this system, a few words on that subject may not be amiss, it being borne in mind that the changing of a system of management is a very serious matter, and cannot be done by a busy superintendent in his spare time.

Method of Introduction.

In order to set tasks we must know beforehand what work is to be done and who is to do it. In order to pay a bonus, we must know after the work is done whether it was done exactly as specified. Hence our first care in starting to introduce this method is to provide means for assigning tasks to the workmen, and means for obtaining such a complete set of returns as will show just what each man has done. When this much has been introduced, the output of a plant is always increased and the cost of manufacture reduced. The next step is to separate such of the work as is standard, or can be readily made standard, from the more miscellaneous work, and set tasks for the standard work. Then we begin to standardise, and as fast as possible reduce the expert and increase the routine work.

As soon as work has been standardised, it can be intelligently planned and scheduled, each workman being given his specific task, for which he is paid a bonus when it is done in the manner and time specified. As bonus is paid only on the written statement of the inspector that the whole task has been properly done: failure to earn a bonus indicates that our plans have not been carried out.

An investigation of every case of lost bonus keeps the management closely in touch with the progress of the work, and as the workmen are ever ready to help disclose and remove the obstacles that prevent their earning their bonus, the managing problem is greatly simplified; for, as one of my co-workers has very aptly put it, "the frictional lag due to the inertia of the workman is changed by the bonus into an acceleration."

With increase in the number of bonus workers, this force of acceleration increases, and not only does the careless worker, who by his bad work prevents some other from earning his bonus, fall into disfavour, but the foreman or superintendent who is lax in his duty finds his shortcomings constantly brought before him by the man whose duty it is to investigate all cases of lost bonus.

The fact that under this system, everybody, high and low, is forced by his co-workers to do his duty, for someone else always suffers when he fails, acts as a strong moral tonic to the community, and many whose ideas of truth and honesty are vague find habits of truth and honesty forced upon them. This is the case with those in high authority as well as those in humble positions, and the man highest in authority finds that he also must conform to laws, if he wishes the proper co-operation of those under him.

THE joint liquidators of the Aluminium Corporation, Limited (in liquidation), have formulated a scheme of reconstruction. It appears that a new company is to be formed, constituted as follows:—Six per cent. debenture stock, £100,000; 50,000 preference shares of £1 each, £50,000; and 300,000 conversion shares of £1 each, £300,000; total, £450,000. The debenture stock will be redeemable at par on December 31, 1950, and will carry interest at the rate of 6 per cent. per annum. The whole issue of £100,000 also carries a participation to the extent of 25 per cent. in the net profits of the new company declared for distribution, and in proportion for any less amount of stock outstanding. The business of the old company is to be transferred to the new company, in consideration of the allotment of 287,205 conversion shares of £1 each, credited as 14s. 6d. paid up, to the liquidators or their nominees, such nominees being the shareholders of the old company, or those in whose favour they may renounce their rights.

IN connection with the intention of Baldwins, Limited, to erect new works at Swansea, it is interesting to note that the company's registered and head office has been removed from Wilden, near Stourport, to Salisbury House, 45, Wind Street, Swansea.

THE IMPERIAL SUNDAY ALLIANCE has lately been formed, with a very influential Executive Committee, for the purpose of endeavouring to secure a more general observance of Sunday as a weekly day of rest. In making an appeal for financial support and personal co-operation, the Committee remark that the results of the combined movement mentioned in an appeal made two years ago, have proved that they expressed the convictions of the great majority of their fellow countrymen. "The facts reveal on all sides," the Committee continue, "a deepening sense of the grave issues which depend upon the use or abuse of the opportunities for rest and worship presented, in the wear and tear of our common life, by this weekly interval of respite from ordinary toil. Industrial workers in every department of labour—mental, not less than physical—have, with striking unanimity, testified to the necessity for safeguarding the principle of one day's rest in seven. Everywhere there is found an insistent desire for wise leadership on this question, and for such assistance as the Legislature can rightly give. In response to this demand, and in pursuance of resolutions adopted at representative public meetings held throughout the land, the Imperial Sunday Alliance, for promoting well-considered action, is now formally constituted."

Workmen and Their Environment.

The effect of environment on the workman, both in regard to health and also working capabilities, is a subject which is often brought up and discussed by men who are prominent in trade circles; but while a considerable stimulus has been lent to the establishment of good surroundings for the workman, we are still far from the desired—we might say even the requisite—stage of progress in this matter. The direct effect of environment on workmanship alone (apart from the character and health of the workman) is fairly generally recognised not only by sociologists, but by employers of labour also. Nevertheless, the matter does not assume the importance it should do, and in the pressure of industrial life is too often relegated to the background, perhaps, in many cases on account of the expense that would have to be incurred in the establishment of better conditions.

FIG. 1.—WORKMEN'S DINING HALL AT THE WORKS OF THE LANARKSHIRE STEEL COMPANY, LIMITED.

At a recent meeting of the Birmingham Association of Mechanical Engineers, MR. FRANK SOMERS, of Halesowen, dealing with the subject of "The Effect that Workmen's Environment has upon Them and Their Work," said that especially in the engineering and other allied trades, many were alive to the necessity of up-to-date plants, but comparatively few people realised the extent to which workmen's environment affected them and their work. A German engineer, he said, who had been talking about what they were doing for their workmen in his country, said he firmly believed that a large measure of their success was due to the conditions under which their men worked.

"It is an undisputed fact," continued Mr. Somers, "that our surroundings have a great influence upon our lives, both as regards our health and also our achievements. I put health first, as the last-named depend mainly upon it. The workman's health is greatly affected by his surroundings, and this, it must be borne in mind, does not end with the present working generation, but must have an influence upon the children who, in time to come, will have to take their fathers' places. One cannot, therefore, attach too much importance to the necessity of having strong and healthy workmen; without these qualities we can have but little hope of successfully competing with other nations in the struggle for supremacy."

Mr. Somers proceeded to contrast the conditions as regards washing and the changing of clothing of the English and the German miners. It is compulsory for every miner in Germany to wash and change his clothes before going home, and the colliery owners are legally obliged to provide the necessary bathing accommodation.

"Turning to the iron and steel industry," said Mr. Somers, "let us see what has been done for their workpeople by the managements of several of the leading works. The directors of the Lanarkshire Steel Company, recognising the advisability of providing dining-room accommodation for their employés to have their meals in peace and comfort, decided, about three years ago, to erect such accommodation at the entrance gate of their works at a cost of nearly £1,200, a consideration which is much appreciated by the workmen. Those who come from a distance and carry their food with them leave it in their numbered divisions as they go in; food brought by the women and children is left in a similar manner. The dining-room is open day and night, and is fitted with a large hot plate for keeping food warm, and also for cooking it; accommodation is provided for cleaning the cooking dishes, and there is always an ample supply of hot water. Suitable lavatory accommodation is provided in a separate adjoining building, where 12 hand-basins, fitted with hot and cold water, are conveniently placed, the Company supplying soap and

towels free. The whole place is well lighted throughout by electricity and maintained at a comfortable temperature in winter by means of hot water pipes. In the entrance hall adjoining the dining-room is a bicycle rack, and there is also a well-equipped ambulance room. The whole is in the charge of one attendant, whose sole duty is to keep everything in order.

expense by the Company for their employés, is one of the best equipped in existence, the men's comfort being greatly studied. There is a separate room for cooking, and also a separate dining-room for the staff. The large dining hall is also used for various purposes, such as dances and entertainments, and on occasions as a training hall for the football club.

"At Haniel & Lueg's Works, in Germany, each work-

FIG. 2.—WORKMEN'S LAVATORY AT THE WORKS OF THE LANARKSHIRE STEEL COMPANY, LIMITED.

FIG. 3.—WORKMEN WASHING BEFORE GOING HOME. WORKS OF MESSRS. HANIEL & LUEG, GERMANY.

"In connection with the motor industry, mention may be made of the works of the Austin Motor Company, Limited, very pleasantly situated at the foot of the Lickey Hills (Worcestershire). The large mess-room, which has been erected here at very considerable

man on arriving at the particular shop at which he is employed, takes off his outer garments and dons his overalls in a special room provided for that purpose, which, in addition to ample washing accommodation, contains a separate lock-up cupboard for

each man. Before taking meals, as also before leaving the works, the men invariably have a wash. The provision is sufficient to permit all the men washing at the same time. The basins are divided into an upper and lower portion, the lower portion being used for the hands and thus ensuring clean water in the upper portion for the face. Meals, in the warm weather, are taken out of doors at tables ranged around the machine shop, the place more resembling a garden than the inside of a large works. In the winter months, meals are taken in the mess room, which is in charge of an attendant who sees to the heating of the men's food, etc. In this room a suitable library is also provided. There are baths for the use of the workmen free of charge after working hours; they are not compulsory, but are made frequent use of. Special bath rooms are provided for the use of the foremen and staff, the last-named paying 1d. each for the use of towels and soap. There is a very efficient ambulance corps under the foremen's leadership, whilst the gatekeepers are instructed by medical doctors to give first-aid in the

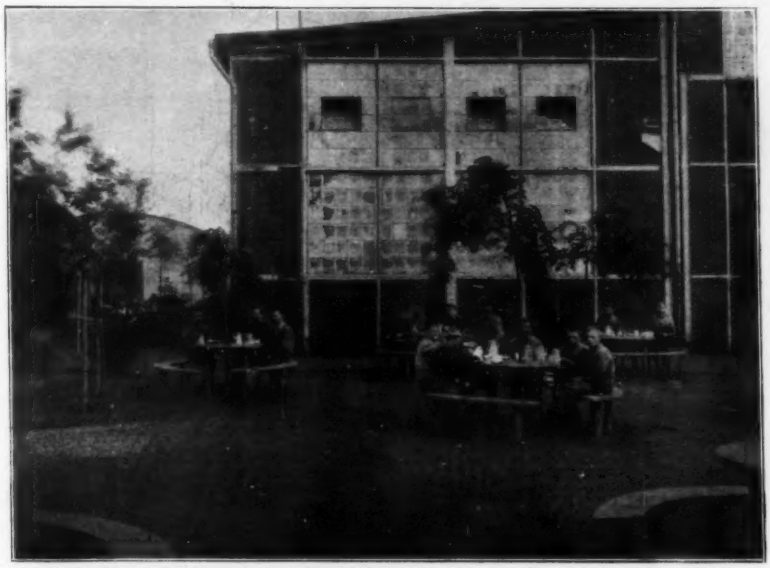


FIG. 4.—WORKMEN AT THEIR MEAL. WORKS OF MESSRS. HANIEL & LUEG.

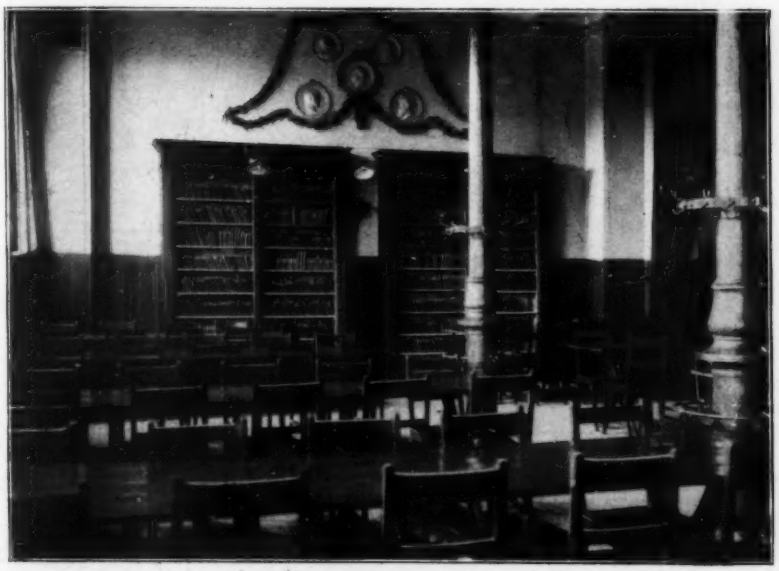


FIG. 5.—WORKMEN'S MESS ROOM AND LIBRARY. WORKS OF MESSRS. HANIEL & LUEG. V388

dressing of wounds and setting of limbs, etc., for which purpose there is a small works surgery.

"At the works with which I am connected at Halesowen, we have during the last year or so put in lavatories for the men, and also made an open air swimming bath.

FIG. 6.—WORKS AMBULANCE CORPS: WORKS OF MESSRS. HANIEL & LUEG.

"Some firms have, I am aware, provided mess rooms and wash places for their workmen, only to give them up, owing either to the men not using or else misusing them. To say that Englishmen will not wash before going home, or eat their meals off tables, is to acknowledge that they are lacking in the civilisation of the German. The Germans, however, did not make a success of their venture in a day. After allowing men by years of practice to acquire the habit of eating their meals anywhere and anyhow, and to go about dirty, it requires a certain time to educate them up to a more civilised state of mind."

We reproduce herewith illustrations of some of the equipments referred to by Mr. Somers.

CONCILIATION IN THE FOUNDRY TRADES.

As we announced in our last issue, the ironfounders of Lancashire have formed a Conciliation Board to deal with labour disputes. The last of a series of conferences between representatives of the Lancashire Ironfounder Employers' Association and representatives of the various Lancashire branches of the Society of Ironfounders was held at Manchester, last month, when the work was brought to a successful conclusion. The Conciliation Board will have jurisdiction over the whole of Lancashire and a portion of Cheshire, and will represent about 150 firms and between 6,000 and 7,000 men. The chairman of the Board is Mr. R. Matthews (of Armstrong, Whitworth & Company, of Manchester), President of the Manchester Employers' Association, and Mr. Arthur Henderson, M.P., representing the men, is the vice-chairman. The organisations represented on the Board on the employers' side are the Manchester Employers' Association, the Manchester Master Ironfounders' Association, and the Employers' Associations of Bolton, Oldham, Blackburn, Burnley, Preston, Wigan, Rochdale, and St. Helens. All questions in dispute are to be referred to a Standing Committee of 14—seven on each side. The employers will be represented on this Committee by Messrs. R. Matthews (Manchester), chairman; W. Hodgson (Salford), A. Reason (Bolton), W. Livsey (Blackburn), E. Keighley (Burnley), J. H. Toulmin (Preston), T. A. Walker (Wigan), and L. A. Porritt (Rochdale). The workmen's representatives are:—Messrs. Arthur Henderson, M.P. (vice-chairman), F. Williams (secretary), J. Bell (Stockport), T. Forsyth (Barrow), A. Jolly (Warrington), J. Langfield (Burnley), E. Wilkinson (Manchester), and R. G. Williams (Liverpool). All questions of difference are to be submitted first to the Standing Committee. If this Committee are unable to agree, a reference is to be made to the full Board. Failing a settlement by the Board, the difference may, by common consent, be submitted to three disinterested gentlemen mutually approved by the Board, and their decision (or the decision of a majority) is to be binding and conclusive. If the Board fail to agree on the choice of three referees each party is to select its own referee, and the two thus chosen are to nominate a third; and again their decision or the decision of the majority is to be binding. One of the rules provides that there shall be no stoppage of work in the nature of a strike or lock-out.

PROPOSED NEW FRENCH TARIFF ON IRON AND STEEL.

Important changes in the Customs Tariff have been recommended by the French Parliamentary Customs Commission, and these are expected to be submitted at an early date to the Chamber of Deputies. The proposals involve a serious increase in the duties chargeable upon many kinds of iron and steel, the details of which are set out below, the rates being per 100 kilos, unless otherwise stated: —

Tariff No.		Present Tariff. General.	Present Tariff. Minimum.	Proposed Tariff. General.	Proposed Tariff. Minimum.
		Fcs.	Fcs.	Fcs.	Fcs.
205	Foundry iron and forge pig, under 5 per cent. manganese	2.00	1.50	2.25	1.50
	Foundry iron or spiegel iron, over 5 per cent., under 15 per cent. manganese	,,	,,	3.00	2.00
	Spiegel iron, 15 per cent. to 25 per cent. manganese	,,	,,	3.75	2.50
	Ferro-manganese, over 25 per cent. manganese	4.75	3.50	5.25	3.50
	Manganese metal, over 95 per cent. manganese	,,	,,	75.00	50.00
	Ferro-silicon and silico-carbide, over 5 per cent. up to 20 per cent. silicon	,,	,,	5.25	3.50
	Ferro-silicon and silico-carbide, over 20 per cent. up to 70 per cent. silicon	,,	,,	7.50	5.00
	Ferro-silicon and silico-carbide, over 70 per cent. up to 95 per cent. silicon	,,	,,	10.50	7.00
	Silicon metal, over 95 per cent silicon	,,	,,	37.50	25.00
	Silico-spiegel, over 16 per cent. up to 30 per cent. silicon and manganese	,,	,,	5.25	3.50
	Silico-spiegel, over 30 per cent. silicon and manganese	,,	,,	7.50	5.00
	Ferro-chrome, over 10 per cent. up to 25 per cent. chrome	,,	,,	5.25	3.50
	Ferro-chrome over 25 per cent. chrome and				
	6 per cent. and more carbon	,,	,,	15.00	10.00
	2 per cent. up to 6 per cent. carbon	,,	,,	30.00	20.00
	1 per cent. up to 2 per cent. carbon	,,	,,	45.00	30.00
	Under 1 per cent.	,,	,,	60.00	40.00
	Chrome metal, over 95 per cent. chrome	,,	,,	75.00	50.00
	Tungsten, pure, or contained in iron alloy	,,	,,	60.00	40.00
	Molybdenum, Titanium, pure or alloyed with iron	(As *produits chimiques*)		150.00	100.00
	Vanadium, pure or alloyed with iron	(As *métaux précieux*)		600.00	400.00
	Ferro-aluminium, under 10 per cent. aluminium	4.75	3.50	5.25	3.50
	Ferro-aluminium, 10 per cent to 20 per cent. aluminium	9.00	7.50	11.25	7.50
	Ferro-aluminium, 20 per cent. or more aluminium	,,	,,	60.00	40.00
532	Detached parts of machines and shafting, in moulded cast-iron, *not malleable*, turned, filed, or adjusted, weighing:				
	Over 1,000 kgs.	18.00	12.00	18.00	12.00
	,, 200 kgs. to 1,000 kgs.	18.00 / 20.00	12.00 / 15.00	22.50	15.00
	200 kgs. and less	20.00 / 30.00	15.00 / 20.00	30.00	20.00
	Roller cylinders; cylinders, etc., for crushers; mill cylinders, in chilled cast-iron, turned, filed or adjusted, fitted or not on iron and steel shafting, weighing:				
	Over 1,000 kgs.	18.00	12.00	21.00	14.00
	,, 200 kgs. to 1,000 kgs.	18.00 / 20.00	12.00 / 15.00	25.50	17.00
	200 kgs. and less	20.00 / 30.00	15.00 / 20.00	33.00	22.00
533	Detached parts of machines, of brake gear and of shafting, in iron or steel wrought or stamped, in moulded iron or steel, or in malleable cast-iron:				
	In malleable cast-iron, ordinary iron or steel, weighing: Over 300 kgs.	rough		10.00	8.00
		worked		20.00	12.00
	,, 100 to 300	rough		10.00	8.00
		worked		25.00	15.00
	,, 15 to 100	rough		10.00	8.00
		worked		40.00	25.00
	,, 1 to 15	rough		10.00	8.00
		worked		40.10	25.00
	1 kg. or less	rough		10.00	8.00
		worked		50.00	35.00
	In special steel containing over 5 per cent. manganese or similar metal. Over 300 kgs.	rough		10.00	8.00
		worked		20.00	12.00
	,, 100 to 300	rough		10.00	8.00
		worked		25.00	15.00
	,, 15 to 100	rough		10.00	8.00
		worked		40.0	25.00
	,, 1 to 15	rough		10.00	8.00
		worked		40.00	25.00
	1 kg. or less	rough		10.00	8.00
		worked		50.00	35.00
	Straight axles, fitted, for rail and tram rolling stock			15.00 / 20.00	10.00 / 15.00	22.50	15.00
552	Moulded cast-iron goods, not malleable, rough, merely trimmed: Railway chairs (*coussinets*), paving plates, hearth-plates, open mould (*coulée à découvert*)			3.00	2.50	4.15	2.75
553	Straight cylindrical pipes, unworked, for guttering, usual length 7 mm. thick and over. Solid and hollow columns, unornamented frames of columns merely pierced, grate-bars, straight solid-section bars, large vats for industrial use, sewer plates, (*trappes de regard*) and similar goods, roughly moulded			4.00	3.50	6.00	4.00
	Straight cylindrical pipes, unworked, for guttering, usual length under 7 mm. thick. Pipes called "guttering joints," (*raccords de canalisation*), such as elbows, branching, straight joints (including joints with rough flange drilled with pipe-borer)			4.00	3.50	7.50	5.00
554	Machine and ornamental cast-iron, ordinary moulding, weighing:						
	Over 100 kgs. per piece			6.00	4.00	6.00	4.00
	100 kgs. and less per piece			8.00	6.00	9.00	6.00
555	Cast-iron special mouldings, consisting of large plates of no great thickness, steam and hydraulic motor parts, parts of grease-boxes for rolling stock, etc., weighing:						
	Over 60 kgs.			6.00	4.00	10.50	7.00
	12 to 50 ,,			7.00	5.00	13.50	9.00
	under 12 ,,			8.00	6.00	19.50	13.00
556	Moulded cast-iron goods (other than machine parts) turned, polished, or adjusted, tinned, coppered, bronzed, varnished, enamelled, or made inoxydizable			15.00	10.00	15.00	10.00
556 *bis*	Chilled cast-iron goods. (*Ouvrages en fonte trempés en coquille*): rough, simply trimmed:						
	Over 500 kgs			6.00	4.00	6.00	4.00
	,, 200 to 500			6.00	4.00	10.50	7.00
	,, 100 to 200			6.00	4.00	13.50	9.00
	100 kgs. and less			6.00	4 00	16 50	11.00
557	Stoves, fire-places, heating apparatus, (*calorifères*) kitchen stoves, kitcheners, in cast-iron, cast-iron and sheet-iron, or in sheet-iron; and detached parts of these goods, ornamented or not, unpolished, untinned, undecorated with varnish or enamel			12.00 / 5.00	8.00 / 4.00	12.00	8.00
	Same goods, containing cast-iron parts, polished, tinned, decorated with varnish or enamel			12.00 / 15.00	8.00 / 10.00	15.00	10.00
	Same goods, in sheet-iron decorated, varnished or enamelled, in sheet-iron decorated, etc. with cast-iron parts, decorated, enamelled, or not			12.00	8.00	23.00	15.00

Protest by the British Iron Trade Association.

In reference to the proposed changes in the Customs' Tariff on iron and steel imports, the British

Iron Trade Association have transmitted a letter to the Board of Trade giving a summary of the opinions expressed by representative iron and steel manufacturing firms throughout the United Kingdom, entering a strong protest to the Board of Trade against the proposed increases in the French tariff, and urging that everything possible should be done to prevent the proposals being carried into effect.

It is pointed out most emphatically by the Association that the proposed new classification and high rates for steel and machine tools are of such a serious nature that, if carried out, they would effectively close French markets against British exporters, and at the same time increase the cost of steel in France, and, consequently, of machines manufactured therefrom, thus adding to the cost of production where such machinery is used.

The earnest hope is expressed that the French Government will decline to ratify these proposed increased rates, for the reason that they would seriously injure France's largest customer, nearest neighbour, and best friend, and would tend to disturb the amicable relations now existing between the two countries.

DANGEROUS GASES IN FACTORIES.

The Factory Department of the Home Office has issued a memorandum relating to the causes of accidents arising from dangerous gases and the best means for their prevention. There has been great extension of late in manufacture and use of water gas and other gases of a similar nature (suction gas, Dowson gas, Mond gas, power gas, producer gas, blast-furnace gas, etc.), for driving gas engines, heating furnaces and boilers in factories, welding, soldering, and many other industrial purposes. The particular danger associated with all these gases is that of poisoning by carbonic oxide (carbon monoxide, CO), which is also a constituent of ordinary coal gas; but whereas the proportion in coal gas varies from 4 to 12 per cent., in carburetted water gas it reaches 30 per cent., and in uncarburetted water gas, 50 per cent. The other gases named above usually contain from 10 to 25 per cent. The annual reports of the Factory Department during the last eight years show a steadily increasing number of reported cases of poisoning by carbonic oxide on manufacturing premises. Thus in the five years 1899 to 1903 there are references to 51 cases (17 fatal), in the two years 1904 and 1905 to 57 (18 fatal), and in the two years 1906 and 1907 to 136 (14 fatal). The lessened mortality is due possibly to better knowledge of the methods of resuscitation.

Precautionary Measures.

The precautionary measures to be considered must vary somewhat according to the manner in which the gas is manufactured and used in different works, but the following are of general application:—

(1) The structural conditions should be such as not to entail unnecessary risk; thus: (*a*) The suction or other gas engine should not be in a confined space or in a basement or sunk room, but in a room or shed properly lighted and adequately ventilated (by special openings and by a fan where practicable) to the outer air, and either without doors or with doors cut away at the top or bottom. (*b*) The air intake for the engine should be from the open air, and not from the engine house itself. The same observation applies to the silencer and air-box, if any. (*c*) The vent pipe through which the gas main to the engine is cleared of air, or any similar vent pipe, should never end inside a building, but always outside, and at least 6 ft. from the ground. (*d*) The openings giving access to any part of the gas circuit should be few, and in positions as safe as possible, and opened only in cases of real need, and by responsible persons.

(2) A competent person should be made responsible for inspecting at stated short intervals all valves and connections, to see that there is no leakage; and for keeping a signed and dated record of such inspection.

(3) A notice, mounted on a board, should be affixed in the engine room or gas-plant house.

(4) No person should be allowed single-handed to execute work in a place where exposure to the poisonous gas is to be anticipated.

(5) No workman should enter, or approach when opened, the holder or other part of the gas circuit until the gas has been well flushed out by fresh air.

(6) A cylinder of compressed oxygen, fitted with lever key, nipple and union, and rubber gas tubing with mouth-piece, should be kept in constant readiness. The apparatus should be in charge of not less than two persons instructed in its use. At least once a month it should be examined by them, when the condition of the mouthpiece and of the rubber tubing should be observed. If the rubber becomes hard and dry, warm water will restore the pliability.

(7) Ropes should be provided for rescue purposes, and the place where they are to be found stated on the notice (par. 8). Where dangerous work is foreseen, special rescue appliances should be supplied, such as those now kept in many chemical works and coal mines; they supply the rescuer with air or a mixture of oxygen and air, so that he does not breathe the poisonous gas.

(8) Further notices should be affixed in the works, explaining the deadly nature of the gas, the symptoms of poisoning, and the means of rescue and "first-aid."

(9) The workmen should be practised in rescue drill, including the use of the appliances provided. They should be further instructed by a medical man in artificial breathing and administration of oxygen. They should be especially warned of the danger of exposing a "gassed" person to cold.

(10) Men in charge of any engine worked by poisonous gas, or of any apparatus in which such gas is stored, or otherwise exposed to risk of inhaling it, should be free from any disease of the heart or lungs. Employers would do well to cause such persons to be medically examined and certified.

Remedies.

The appropriate remedies for poisoning by carbonic oxide are: fresh air, artificial breathing, administration of oxygen, and the application of warmth. They should be applied without any delay, and hence the importance of competent "first-aid."

TECHNICAL EDUCATION IN AMERICA.

At the monthly meeting of the Newark (N.J., U.S.A.), Foundrymen's Association on February 3, the members discussed the advisability of advocating a foundry course in the Newark Technical School, after an address by Director Charles A. Colton, of that Institution. A large part of the membership of the Association is composed of firms who do not conduct foundries alone, but maintain them in connection with their manufacturing plants. Professor Colton, in the course of his address said:—

"Industrial education in the real sense should not be attempted before the scholar is mentally and physically capable of grasping it, which would be at about 14 years of age. To be sure, the way should be prepared for it before this time in the grammar schools, followed by preparatory vocational schools.

"By some persons, manual training is considered industrial education, when in fact it is simply cultural and disciplinary. It is good as far as it goes, but is no more industrial education than the courses in writing and drawing as given in the public schools are. Industrial education must be provided for those already in the industries and those who expect to be so employed. Those in the first-class will necessarily be obliged to attend evening schools having courses of study, giving instruction in the theory and technique of the industries in which they are employed. For those in the second-class, day schools, which shall be preparatory trade schools, if you choose to call them so, should be provided, so that scholars from the grammar courses can be fitted to take up a trade in a shop. It must not be expected that scholars in such schools will become experts, for they would probably not be able to remain long enough out of the wage-earning class to do so even if opportunity were provided, and they must enter the shop as apprentices.

"Before the establishment of such schools there must be created the mental attitude on the part of those who are to be instructed in them, and a different class of instructors with much broader views, broader methods and broader sympathies than the average teacher must be provided.

"Concerning the course of study which it is proposed to organise for your employés, namely, moulders, I should propose something like the following as a tentative plan:—

"The cupola furnace; its construction, operation, air supply, blowers.

"Fuel; its character and results of its combustion.

"Pig-iron; its grades, composition and peculiar action of its constituents other than iron on the quality of the castings.

"Moulding; preparation, gates, vents, etc.

"Moulding sands; varieties and uses.

"Cores, drying ovens, foundry facings, blowholes.

"Brass founding; furnaces, charges, etc.

"Malleable castings.

"Isometric drawing, cost keeping accounts.

"Such a course of study would probably require the attendance of the students four evenings per week for two school years.

"It is proposed to start the course with the beginning of the next school year in October. The technical school does not propose to start a foundry. There will be no cupola furnace in the equipment and no moulds or castings will be made. Specimens of good and bad work and the raw materials used will be provided as far as possible by way of illustration.

"The object of the course is to teach the theory and technique of moulding and foundry practice to moulders and pattern-makers if any such desire to attend."

In the discussion which followed, it was the consensus of opinion that it would be well to advocate the adoption of Professor Colton's recommendations.

SHEFFIELD FOUNDRYMEN.

At the February meeting of the Sheffield and District Branch of the British Foundrymen's Association, in the absence of Mr. Pilkington, the President, Mr. Percy Longmuir occupied the chair before a good gathering of members.

Mr. Addy, the lecturer, opened with a brief historical sketch of the process of iron-making from the times of the ancient Britons onwards. Considering modern practice, Mr. Addy spoke strongly in favour of the earlier product in the shape of cold blast pig-iron. He contended that the great improvement as regards output which has characterised the introduction of the use of hot blast, and larger furnaces, is only, however, to be obtained by sacrificing to some extent the quality of the iron produced.

After discussing furnace design Mr. Addy dealt briefly with cupola practice, and then considered in a very able manner the mechanical testing of the cast iron.

The tensile crushing, torsion, and transverse tests were fully explained and illustrated. It was shown that, contrary to general belief, a bar does not suffer in transverse test, by having the "skin machined off." The effect of the shape and method of clutching tensile bars were considered, screwed ends being advocated. The lecture closed with some striking examples of how pillars and girders break down under test.

A NEW HIGH-SPEED STEEL.

An announcement made by Professor Arnold, the head of the Metallurgical Department of the Sheffield University, regarding recent experiments in the manufacture of high-speed steel, in the course of the second of his series of lectures before the Royal Institution of Great Britain, created very considerable interest and speculation throughout the metallurgical world. The Professor stated that a certain firm were about to place on the market a high-speed steel which would quadruple the efficiency of any existing steel of a similar type. The steel is being manufactured by Messrs. Jonas & Colver, Limited, of the Continental Steel Works, and the Novo Steel Works, Sheffield, and is the direct result of experiments extending over a lengthy period almost solely conducted with the object of producing a steel for the American markets that would not infringe any of the patents then supposed to be exclusively held by the Bethlehem Steel Company.

Tests made by Messrs. Jonas & Colver reveal at least four times the cutting power of any other known steel of this class.

Experiments were conducted at the Continental Steel Works for a period extending over many months, and the result was the production of a new steel which was hardened in water, and which showed a remarkable increase in hardness over the present existing high-speed steel. The new steel has been named "Novo Superior," the older high-speed steel for the manufacture of which the firm have so long enjoyed a universal reputation, having been known as the "Novo" brand. An interesting experiment recently conducted by the makers showed that a tool made from the steel could be hardened seventeen consecutive times in cold water without showing signs of cracking.

The Uses and Testing of Manganese Bronze.*

By C. R. Spare. †

The best present-day alloys of manganese bronze are the results of years of scientific research by several of the largest manufacturing concerns in the world, who maintain chemical and physical testing laboratories in connection with their brass foundries. Of all the metal industries, brass founding is almost the last to pass from the empirical and rule-of-thumb to a scientific metallurgical basis. In fact, the majority of the brass and bronze manufacturers have never used chemical analysis or a testing machine and therefore have only a general idea of the composition and physical properties of their products.

Conditions are changing, and engineers have multiplied powers and manipulated pressures beyond all former figures. Machinery is more powerful, more complicated and more severely tested than ever before, and while steel and other industries have made great advances and kept pace with the requirements, the same ratio of improvement has not been maintained in the copper and brass metals, excepting in the case of the high tensile strength manganese bronzes.

There are several brands of manganese bronze on the market, each with its own characteristics, which are determined by the chemical composition and the process of manufacture. While upon analysis some of these bronzes do not reveal striking differences in composition, yet these alloys are susceptible of wide variations in physical properties by slight changes in composition, difference in quality of raw materials and methods of melting and mixing.

Certain impurities affect very injuriously the strength and ductility of manganese bronze, causing brittleness and crystalline texture.

Manganese bronze first found its important practical application in the manufacture of propeller wheels for ships. Now, cast iron and cast steel have been almost universally displaced by it; not only naval vessels but the merchant ships of the world have adopted it. Marine engines have been increased to such vast powers, especially during the past 10 years, and since the advent of the steam turbine, that 20,000, then 40,000, and now 70,000 indicated horsepower are transmitted through manganese bronze propeller wheels. In some ships the speed runs upward of 300 revolutions per minute.

This bronze is practically incorrodible in sea and alkali waters. Likewise dilute acids and acid mine water are withstood very successfully. Long time tests have been made with various acids and mine waters. Cast blocks of manganese bronze immersed in the most acid mine water in Pennsylvania, containing about 300 grains sulphuric acid per gallon, for one year, showed no material corrosion, and a test piece cut from this metal showed no diminution in tensile strength over a duplicate specimen previously tested.

Test pieces cut from cast propellers should show an average ultimate tensile strength of 70,000 lbs. per square inch, elastic limit of about 35,000 lbs., or one-half the ultimate; elongation in 2 in., 25 per cent., and reduction of area 25 per cent. The reduction of area follows the elongation closely in cast manganese bronze.

These figures can be varied to suit requirements. A soft manganese bronze having an ultimate strength of 60,000 lbs. per square inch and 40 per cent. or 50 per cent. elongation in 2 in. is the lower limit, while an exceedingly hard manganese bronze can be made to test over 90,000 lbs. per square inch, with even as much as 30 per cent. elongation. The methods of testing manganese bronze physically do not differ materially from the standard methods for steel. Test pieces according to the standard U.S. Government sizes, 0.505 in., 0.798 in., or 1,000 in. diameter are machined 2 in. between punch marks and threaded. In the case of castings there is not a sharply defined elastic limit and the yield point cannot be determined by the drop of the beam. Mutliplying dividers, or a standard extensometer will establish quite closely the point at which an appreciable change in the rate of stretch takes place.

In compression, cast manganese bronze, if properly made, shows an average elastic limit of 35,000 to 40,000 lbs. per square inch, and a maximum crushing load of 90,000 to 100,000 lbs. per square inch. Rolled or forged manganese bronze tests 50,000 to 60,000 lbs. elastic limit and as high as 130,000 to 150,000 lbs. maximum crushing load.

Manganese bronze can be rolled or forged readily at a red heat with the production of an exceedingly tough, dense and close-grained metal. Microscopic examination of cast manganese bronze, after polishing and etching, reveals a very homogeneous and uniformly grained metal, but after rolling or forging to a sufficient reduction, the structure is reduced to from 1/30 to 1/50.

Rolling or forging raise the proportional elastic limit to from 45,000 to 75,000 lbs. per square inch, depending upon the finishing temperature and the amount of work done on the metal. Likewise the ductility and toughness are increased without, however, a corresponding increase in ultimate strength.

Forged and rolled rods find a wide application as piston rods, shafts, axles and for all purposes where a metal of equal strength and toughness to carbon steel is desired and which will not rust or corrode in the atmosphere, mine or sea water.

An especially soft and tough metal is made to resist vibratory and sudden stresses and shocks. It is used under very severe conditions in modern naval ordnance. It is also finding application in staybolts for locomotives. This bronze tests 40 per cent. to 50 per cent. elongation, with about 60 per cent. reduction of area.

Thus only a few of the better known applications of manganese bronze have been pointed out. The electrical industry is calling for it for turbo-generator sets which are run at speeds up to 4,000 revolutions per minute and the blades of the steam turbine are satisfactorily made of extruded manganese bronze shapes. In this case the erosive action of high pressure steam is a severe condition, under which most metals fail.

Automobiles with gasoline motors of 60 and even as high as 130 h.p., at speeds of 1,000 to 1,500 revolutions per minute and running over all kinds of roadbeds at 60 and 100 miles an hour have stimulated the improvement of the materials entering into their construction more, perhaps, than any other modern machine. Accordingly, manganese bronze, formerly used almost exclusively in warships, has been adapted to produce forgings and castings which will not crystallise or fail under similarly severe conditions.

* Abstracts of a paper read at a meeting of the American Society for Testing Materials.

† Of the American Manganese Bronze Co., New York.

Inventions.

Applications for Patents

—o—

An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

—o—

1909.

1339. Aluminium alloys. E. J. de St. Laurent, E. W. Lancaster, H. T. McNeale, and J. W. Collins, 2, Norfolk Street, Strand, London.
1365. German silver. W. R. Barclay and J. Rodgers, 24, Norfolk Row, Sheffield.
1738. Tapered slide ingot mould. H. E. Ward, Roseleigh, Albany Road, Norton-on-Tees.
1786.*Crucible furnaces. (Kroeschell Brothers Company, United States.)
2108.*Metal turning tools. J. Hartness.
2314. Iron mould. J. Sharp, 58, South William Street, Perth.
2725. Crucible furnaces. P. J. Mallmann.
2938.*Recovery of metalliferous fumes obtained in roasting or smelting ores. A. M. G. Sebillot.
3599.*Electrical induction furnaces. C. Grunwald.
3,747.*Construction of oil-fired furnaces, more particularly annealing furnaces. (Schrauben- & Schmiedewarenfabriks Akt.-Ges. Brevillier & Company and A. Urban & Sohne, Austria.)
3,789. Furnaces applicable for annealing, puddling, etc. Z. W. Onions and C. H. Bonn, 96, Buchanan Street, Glasgow.

Abstracts of British Patent Specifications recently accepted.

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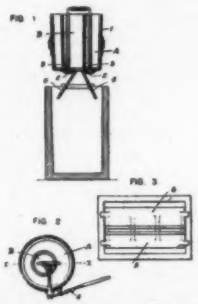
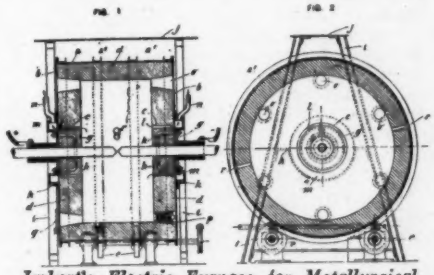
9,205 (1908). *Method of Casting Compound Ingots.* W. H. Connell, 7, Colonial Place, Pittsburg, Pennsylvania, U.S.A., Treasurer of the American Bridge Company.—The invention has for its object the bringing together of two bodies of metal while in a molten condition under such conditions that the metal of the two bodies will intermingle in the interior of the ingot, but will maintain their distinct characteristics at opposite sides of the ingot. Fig. 1 is a sectional elevation of a form of apparatus adapted for the practice of the invention; Fig. 2 is a plan view of a suitable form of ladle; and Fig. 3 is a plan view of a mould having the deflector in position thereon. The two kinds of metal are simultaneously teemed into the mould, care being taken that the two streams of metal shall not inter-



Improved Method of Casting Compound Ingots.

mingle. Preferably the two streams should be separated as widely as possible while flowing into the mould, and the flowing together of the two metals should take place only after the inflowing streams have reached the bottom of the mould or the metal previously formed. The inventor has found that when two bodies of metal are thus brought together in a mould there will be sufficient agitation to cause a thorough commingling of the metals in the interior of the ingot, and that the metals will be commingled in approximately equal portions in and adjacent to a certain plane, but that the percentage will change on opposite sides of such plane, that is, the percentage of one metal will decrease and the other will increase from such to the sides of the ingot, where only one metal will be found. In an ingot cast in this manner no plane of cleavage will be formed, but one metal will be found on one side of the ingot and will gradually decrease in quantity towards the other side, while the other metal will correspondingly increase, thus avoiding sharply defined zones. The ladle 1 is divided into two compartments A and B, each provided with outlet openings 2 controlled by plugs 3. As both ports should be opened simultaneously the plugs are connected to a common operating lever 4. When it is desired to produce ingots in which the proportions of the two metals vary provision should be made, either by varying the sizes of the outlets or the movement of the plugs, so that the flow of the metals will vary with the proportions desired in the ingot. It will be understood that compartments and ports in the ladle may be so arranged that the streams of metal will flow closely adjacent to opposite sides of the ingot. But it is preferred that the stream of metal should be spread out, and to that end the inventor employs deflecting plates 5 and 6, which are supported on the ingot mould. As the streams of metal strike these plates they are spread out and deflected towards opposite sides of the mould. When these flat streams strike the bottom of the mould or metal contained therein they will flow laterally and meet in a plane, the position of which will vary in accordance with the relative volumes of the metals.

17,281 (1908). *Electric Furnaces.* A. H. Imbert, 75, Avenue de la République, Grand-Montrouge, Department of the Seine, France.—This invention relates to electric furnaces for metallurgical uses of the kind comprising a revoluble drum lined with a material of low electrical conductivity and suitably mounted for rotation about the electrodes. The furnace is so devised that in order to avoid friction about the electrodes, and also to avoid the breaking of the latter, which would

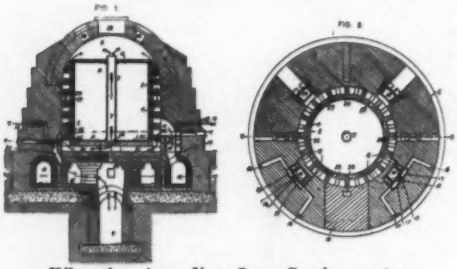


Imbert's Electric Furnace for Metallurgical Purposes.

almost inevitably happen in the event of any longitudinal or transverse movement of the drum, the end walls of the latter are divided into two concentric portions, the central ones of which carry the electrodes and remain stationary while the rest of the furnace, including the end walls proper or outer annular portions of the end walls, revolves about the central portions. The end walls proper are integral with the circumferential wall, and means are provided both for making a gas tight joint between the end walls proper and the

stationary portions, and also for carrying away the gases from the interior of the furnace. The materials, while undergoing treatment within the drum, are never within the cone of shade of the arc, but are at all times directly under the arc and heated simultaneously by radiation from the arc and by the circumferential walls of the furnace. By so constructing the furnace there can be attained an exceedingly high temperature, and an even and thoroughly efficient heating of the material. This form of construction has the advantage that the overhanging or unsupported portions of the electrodes are quite short. The central stationary portions at the ends have provision whereby they can be cooled by a circulation of water therein. In the end walls of the drum there may be provided, respectively, two or more orifices for charging the furnace and a like number for discharging same, instead of, as has heretofore been suggested, one orifice at each end; and the respective discharging orifices are immediately opposite to the several charging ones. Fig. 1 is a longitudinal axial section of a furnace embodying this invention; Fig. 2 is a transverse section of the same furnace.

23,663 (1907). *Kilns for Annealing Iron Castings and for Case-Hardening.* H. Mote, of 9, Bloomfield Road, Coventry, foundry manager, and W. P. Gibbons, of Dibdale Works, Lower Gornal, Stafford, managing director of Gibbons Brothers, Limited.—This invention has reference to kilns which are gas fired, and are constructed for annealing iron castings and for case-hardening. Fig. 1 is a sectional elevation taken on line U U of Fig. 2 of a kiln constructed in accordance with this invention, while Fig. 2 is a sectional plan of the same taken on line V V of Fig. 1. The kiln, which is preferably of circular shape, and made with a domed top, is provided with a cast-iron inner annealing chamber 2, which is also circular, and has a flat bottom 3, which stands on the floor of the kiln. An annular space 4 between the inside of the kiln wall 5 and the inner annealing chamber is filled with chequer brickwork up through the interstices of which the



Kilns for Annealing Iron Castings, etc.

flames pass from the gas mouths. In the floor of the kiln are inner flues for the better distribution of the heat. The annealing chamber has a central downcast flue 7, down which the heat passes from the space 8 in the dome of the furnace above the top of the chamber and through the passages in the floor of the kiln to the waste heat flue 9 underneath. In the annealing chamber the castings are placed through an ordinary side opening 10, together with the ore or other material, until the chamber is filled. The top is then covered over with iron plates 11, with firebrick tiles 12 on the top, through which the top of the vertical flue projects. The kiln has a circular gas flue 13 below the floor receiving gas from the gas producer. Rising up from this gas flue there are four gas flues 14, which open out at gas mouths 15 into the interior of the kiln. The secondary air enters through the side passages 16 and down the passages 17 to the bottom of the same, and then across into the bottoms of the passages 18 (see Fig. 2), and up to the top of the same and through the air outlet holes 19, where the heated secondary air meets the gas so that combustion takes place. The flames pass up through the chequer work in the annular space and over the top of the same, and down the down-draught flue through the opening 20 in the floor of the kiln, and so on to the waste heat flue.

352 (1908). *Manufacture of Tools of High-Speed and Extra High-Speed Steel.* P. A. Viallon, manufacturer, 102, Avenue Parmentier, Paris.—This invention relates to tools in which the working portion consists of high-speed steel and the body portion of ordinary steel. The two prepared pieces, such for instance as those shown in perspective in Figs. 1 and 2, are first heated to a cherry-red heat; then the nose 3 prepared on the bar of ordinary steel 1 is covered with soldering material; the portion of high-speed or extra high-speed steel 2 is applied thereto; and the whole is heavily pressed. This operation has the effect of melting the soldering material and of producing a primary adherence of the

Manufacture of Tools of High-Speed and Extra High-Speed Steel.

two parts or portions; the tool is again carefully put into the fire, whence it is withdrawn when it has reached a yellow heat, that is, between 2012 and 2372 degrees Fahrenheit. The welding is then finished by hammering lightly at first and then heavily. The tool is thereupon slowly cooled, carefully dressed and finished, and then re-heated to 1,000 or 1,300 degrees Centigrade, so that it can be tempered like an ordinary tool of high speed steel.

6029 (1908). *Refining of Steel in Electric Furnaces.* The Company Bismarckhutte, of Bismarckhutte, near Schwientochlowitz, Upper Silesia. The invention consists in passing the steel previously refined in a basic electric furnace into a crucible, where the emulsified slag separates out and the acid lining of the crucible acts favourably on the steel. The remainder of the slag which has not been separated out by the reaction in the electric furnace settles on the top. Such a separation cannot be produced by prolonged treatment in the electric furnace, for the reason that the disturbance of the material between the electrodes is too violent to permit the settling of the finely divided particles of slag distributed through the metal, and which have not been removed by the reaction in the electric furnace. When allowed to remain in a crucible, however, the influence of the basic electric furnace is counterbalanced, and, further, a favourable amount of silicon is taken up by the steel in the known manner. The process further permits of the production of alloys of iron in an exceedingly controllable manner, or the addition of modifying agents thereto, as is usual in the crucible process. These additions can only be made with great difficulty in the electric furnace, as the temperature conditions in the electric furnace are so variable that when the additions usual in the crucible process are made, totally different results as regards grain and structure of the metal and other physical qualities are obtained. These difficulties can be avoided by passing the steel conveniently in the unalloyed state into the crucible before the addition of the modifying constituents. Likewise, the carbonising can take place in the crucible by means of suitable carbonising agents.

In commercial circles in the North of England the report has been current that Messrs. Beyer, Peacock & Company, Limited, the well-known locomotive-building firm, of Manchester, had decided, owing, it was stated, to heavy local charges and the lack of room for further extensions at the Gorton Foundry, to transfer their operations to the North-East Coast, and that provisional arrangements had been entered into for the acquisition of a large site adjoining the North-Eastern main line at Darlington. The report has been officially denied.

PERSONAL.

MR. H. C. FRICK, of the Carnegie Steel Company, is shortly taking up his residence in London permanently.

THE late Mr. G. B. Rennie, of the firm of J. & G. Rennie, left estate of the value of £96,781 gross.

THE late Mr. Frank Taylor, of the Sandycroft Foundry Company, left estate valued at £253,732, with net personalty £207,908.

THE CHATTERIS ENGINEERING WORKS COMPANY have appointed Mr. A. W. Campbell, A.M.I.M.E., as their London representative.

THE late Mr. James Wright, sole proprietor of the Burnbank Foundry Company, of Falkirk, left personal estate of the value of £132,101.

MESSRS. E. P. ALLAM & COMPANY, of 11, Red Lion Street, Clerkenwell Road, E.C., have removed to 28, Gray's Inn Road, Holborn, W.C.

MR. C G. CLARKE has been appointed London agent of the Birmingham Metal and Munitions Company, Limited, of Kingsway House, W.C.

ON retiring from the position of manager of the Usk-side Engineering Works, Newport, Mr. John Lyle has been presented with a handsome book-case, subscribed for by the employés.

THE late Mr. J. H. Stone, J.P., of Sutton Coldfield, tube manufacturer and brassfounder, of the firm of Messrs. Benton & Stone, Birmingham, left estate valued at £26,652 gross, with net personalty £26,509.

THE late Mr. D. Campbell, of Messrs. Campbell, Binnie & Company, ironfounders and engineers, Parkhead, Glasgow, and Greenfield, Hamilton, left personal estate valued at £51,413.

MESSRS. HARVEY & WILBRAHAM, of 2, Laurence Pountney Hill, London, E.C., have been appointed consulting engineers and technical advisers to Messrs. Mason & Barry.

MR. GEORGE HEGGIE, late of the Milton Iron Works, Glasgow, has been appointed head superintendent of the foundry of the Lidgerwood Manufacturing Company, New Jersey, U.S.A., on the retirement of Mr. Fisher, who has been with the firm many years.

ERNEST SCOTT & MOUNTAIN, LIMITED, have appointed Messrs. Balmer, Lawrie & Company, of Calcutta, as their sole agents in India. Mr. W. C. Mountain, managing director of the above company, is at present in India, visiting both Bombay and Calcutta on business matters.

MR. GEO. H. HASWELL, managing director of Tangyes, Limited, of the Cornwall Works, Birmingham, has retired after having rendered valuable services to the business during a period of 40 years, but he has been requested to continue to hold a seat on the board. Mr. William Tangye has been elected managing director, to succeed Mr Haswell.

MR. J. J. BURTON, who recently resigned his position as a director and secretary of the Cargo Fleet Iron Company, Limited, after being connected with the owners of the works for over 40 years, has now been succeeded in the secretaryship by Mr. Frank Ley, late of the German Verbrand in London, who has taken up his duties this week. Mr. Burton still retains the managing directorship of the Tees Furnace Company, Limited, and of the Roseberry Ironstone Mines.

MR. STANLEY G. FLAGG, SR., whose name is well known in the malleable foundry industry, retired on Jan. 1 from the firm of Stanley G. Flagg & Co., Philadelphia, which he founded in 1856. Mr. Flagg was born in Whitesboro, N.Y., March 13, 1830, and spent the early years of his life in Boston. In 1860 he built shops in Philadelphia, and in 1865 a second plant was built, which was enlarged and re-built in 1879. Both works are still the property of the firm. The Pottstown plant was placed in operation in 1896. The manufacture of small steel castings was taken up by this concern in 1873, and samples were exhibited at the Franklin Institute fair in 1874 and a bronze medal was awarded. At the Philadelphia Centennial exhibit in 1876 also a medal was awarded to the concern. Stanley G. Flagg, Jr., who has been associated with his father since 1882, now undertakes the sole management of the business.

TRADE TALK.

ALFRED HERBERT, LIMITED, of Coventry, have removed their Japanese offices to 14, Yamashita-cho, Yokohama.

ROSE, DOWNS & THOMPSON, LIMITED, of the Old Foundry, Hull, are shortly opening a branch office at Shanghai.

MESSRS. J. F. MACNAB and W. H. LATTA, engineers' factors, etc., Liverpool, trading under the style of J. F. Macnab & Company, and Macnab & Latta, have dissolved partnership.

MR. NEVILLE KAYE has formed a company under the style of Neville Kaye & Company, Limited, Thanet House, 231-232, Strand, London, W.C., to carry on the business of makers of lifting tackle of every description.

S. A. DANIEL, LIMITED, of the Parade, Birmingham, have put down a new foundry in connection with their Edward Street Works. This is an addition to the company's plant, and not a new departure.

J. BEARDSHAW & SON, LIMITED, of the Baltic Steel Works, Sheffield, have appointed Messrs. William C. Yuille & Company, of 60, Brown Street, Glasgow as their agent for Glasgow and the West of Scotland.

THE SUTHERLAND METER COMPANY, LIMITED, Windmill Lane, Birmingham, have built a new factory, the internal equipment of which is nearing completion, at Electric Avenue, Witton, Birmingham.

MESSRS. E. HARGREAVES, D. TAYLOR, and A. HARGREAVES, ironfounders, Halifax, trading under the style of E. Hargreaves & Company, have dissolved partnership, so far as regards Mr. D. Taylor.

THE HOFFMANN MANUFACTURING COMPANY, LIMITED, of Chelmsford, Essex, have, in consequence of the rapid increase in their business in the Midlands, opened an office in Birmingham, at Central House, New Street, under the charge of Mr. A. J. Butlin, district manager.

MESSRS. H. N. KNIGHTS & COMPANY have been appointed sole agents for the London district and the South of England for the Northamptonshire Direct Castings Company, Limited, and Thomas Butlin & Company, Limited, of Wellingborough.

THE FRODAIR IRON AND STEEL COMPANY, LIMITED, Fenchurch House, London, E.C., have obtained the Grand Prix and Gold Medal for their exhibit of special pig-irons and high-speed steel at the Industrial Exhibition in Rome (esposizione del Lavoro & dell'Industria).

THE MANCHESTER CHAMBER OF COMMERCE have decided to establish a testing house for the use of local engineers and metal workers. This will make the third in the district, there being already testing departments at the University and School of Technology, not to mention those at the individual works.

MESSRS. J. R. KELLY & COMPANY, engineers and agents, 25, Bridge End, Leeds Bridge, Leeds, have been appointed sole Yorkshire agents for H. W. Ward & Company, Limited, Lionel Street, Birmingham, for their well-known turret, capstan, and ordinary lathes, milling and drilling machines, and plain and universal grinding machines.

THE PULSOMETER ENGINEERING COMPANY, LIMITED, have acquired the business of Messrs. Easton & Anderson, Westminster (successors to Easton & Company, of Erith), including their goodwill, designs, records, and patterns. The company have also secured the services of the heads of the designing and commercial staff, and are in a position, therefore, to carry on the new work without disturbing their existing business.

MESSRS. MOUNTAIN & GIBSON, tramway and railway engineers, of Elton Fold Works, Bury, have completed negotiations for acquiring the business and works of Thornewill & Warham, Limited, engineers, Burton-on-Trent. The latter offer more facilities, particularly for the heavy work. Some of the machinery will be removed to Burton at an early date, but the Bury Works may probably be retained more or less permanently for the production of some of the firm's specialities of a lighter kind, for which they are more suitable. It is understood that a new company is being formed to take over the combined businesses of Messrs. Mountain & Gibson, and Messrs. Thornewill & Warham, on a larger financial basis.

NEW COMPANIES.

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MALLINSON MACHINE TOOL COMPANY, LIMITED.—Capital £5,000 in £5 shares.

ALUMINIUM FOUNDERS, LIMITED.—Capital £2,000 in £1 shares, to carry on the business of metal founders, etc.

ASPREY ENGINEERING COMPANY, LIMITED.—Capital £10,000 in £1 shares. Registered office: 18, South Bruton Mews, W.

SCOTT ENGINEERING COMPANY, LIMITED.—Capital £4,000 in £1 shares, to acquire patents for inventions relating to improvements in internal combustion engines, etc.

H. J. H. KING & COMPANY, LIMITED.—Capital £10,000 in £1 shares, to acquire the business carried on by the executors of the late H. J. H. King, and to carry on the business of engineers, founders, etc.

ERNEST WEST & BEYHON, LIMITED.—Capital £1,000 in £1 shares, to carry on the business of engineers, coppersmiths, brassworkers, etc. Registered office: 82, Belvedere Road, Lambeth, S.E.

WILLIAM EDWARDS & SON, LIMITED.—Capital £1,000 in £1 shares, to carry on the business of manufacturers of, and dealers in, all kinds of machinery, engines, edge tools, implements, appliances, etc.

DAVID SHANKS & COMPANY, LIMITED.—Capital £2,000 in 1s. shares, to carry on the business of brassfounders, steel-makers, and converters, etc. Registered office: 58, Albert Road, Cisbon Manor, Warwick.

SAMUEL PARKES & COMPANY, LIMITED.—Capital £8,000 in £1 shares, to take over the business of a hardware merchant, manufacturer, and brass and ironfounder carried on by S. Parkes at New Road, Willenhall.

BORYSLAU ENGINEERING AND TRADING COMPANY, LIMITED.—Capital £1,000 in £1 shares, to carry on the business of mechanical engineers, tool-makers, etc. Registered office: 10 & 11, Austin Friars, E.C.

JOHN COATES & COMPANY, LIMITED.—Capital £10,000 in £1 shares (8,000 preference), to take over the business of an engineer, etc., carried on by J. Coates & Company. Registered office: Suffolk House, 55, Laurence Pountney Hill, S.E.

HARDENITE STEEL COMPANY, LIMITED.—Capital £1,000 in £1 shares, to carry on the business of steelmakers, mixers, melters, converters, and refiners of iron and steel, metal workers, metallurgists, etc. Registered office: Royd's Works, Attercliffe Road, Sheffield.

NORTHERN ALUMINIUM COMPANY, LIMITED.—Capital £1,000 in £1 shares, to carry on any business relating to the winning and working of aluminium, etc. Registered office: Caxton House, Victoria Street, Westminster, S.W.

ELECTRO-BRASS COMPANY, LIMITED.—Capital £2,000 in £1 shares, to adopt an agreement with G. Jones, and to acquire from him the inventions referred to therein relating to improvements in polishing, finishing, and brassing zinc or other metal.

BROAD & SON, LIMITED.—Capital £3,000 in £1 shares, to acquire the business carried on at 41-2, Windmill Street, Tottenham Court Road, W.C., as G. Broad & Son, and to carry on the business of brass and bronze founders, metal merchants, etc.

BENGAL FOUNDRY COMPANY, LIMITED.—Capital £5,000 in £1 shares, to take over the business of a hollow-ware manufacturer carried on by S. W. Storey, at 22, Stanhope Street, Liverpool, and to adopt an agreement with J. I. Chesshire.

JOHN SUCH & SONS, LIMITED.—Capital £6,000 in £1 shares (2,500 6 per cent. non-cumulative preference), to acquire the business carried on at King Street Works, Cheltenham, as J. Such & Sons, and to carry on the business of founders, engineers, etc.

DEAN, SMITH & GRACE, LIMITED.—Capital £35,000 in £1 shares, to acquire the business of machine-tool makers, iron and brass founders, etc., carried on by Dean, Smith & Grace, Limited (incorporated in 1898), at Worth Valley Tool Works, Keighley.

ALEXANDER RITCHIE & COMPANY, LIMITED.—Capital £30,000 in £1 shares (15,000 6 per cent. cumulative preference), to adopt an agreement with A. Ritchie, and to carry on the business of ironfounders, etc. Registered office: 12-13, Upper Thames Street, E.C.

AMOS & SMITH, LIMITED.—Capital £80,000 in £100 shares, to take over the business of engineers, boiler and engine-makers, and iron and brass founders, carried on by A. Wilson and W. S. Hide, at Hull, as Amos & Smith. Registered office: Neptune Street, Hull.

T. R. SHERCLIFF & COMPANY, LIMITED.—Capital £10,000 in £1 shares, to take over the business carried on by T. R. Shercliff at the Midland Brass and Copper Works, Burton-on-Trent, as T. R. Shercliff & Company. Registered office: 45 A, Stanley Street, Burton-on-Trent.

CORBET, WILLIAMS & SON, LIMITED.—Capital £12,000 in £1 shares (3,000 preference), to take over the business carried on by M. Rowley-Conwy and F. A. Go'dsmith at the Phœnix Iron Works, Rhuddlan, Flint, as John Williams & Son. Registered office: Phœnix Iron Works, Rhuddlan, North Wales.

JOSEPH JOHNSON'S PATENTS, LIMITED.—Capital £3,000 in £1 shares, to adopt an agreement with J. Johnson, and to carry on the business of iron and metal founders and merchants, stampers, hardware manufacturers, etc. Registered office: 81, Darlington Street, Wolverhampton.

ALEFOUNDER & KING (1908), LIMITED.—Capital £1,500 in £1 shares, to take over certain assets and goodwill of the business of mechanical engineers recently carried on by Alefounder & King, Limited, and to carry on the same. Registered office: 20A, Conewood Street, Highbury, London, N.

ANDERSON'S MACHINE WORKS, LIMITED.—Capital £2,000 in £1 shares, to acquire the business of ironfounders, mechanical engineers, etc., carried on by G. Anderson, at Railway Street, Ballynachinch, co. Down. Registered office: Railway Street, Ballynachinch, co. Down.

C. SHARDLOW & COMPANY, LIMITED.—Capital £2,000 in £1 shares (1,500 preference), to acquire the business carried on by C. Shardlow as Shardlow & Company, and to carry on the business of mechanical and electrical engineers, founders, etc. Registered office: Britannia Foundry, St. Peter's Lane, Leicester.

GLOBE FOUNDRY, STRATFORD, LIMITED.—Capital £5,000 in £1 shares, to adopt an agreement with W. Harris for the acquisition of the business carried on by him at Albert Road, Stratford, E., as the Globe Foundry, and to carry on the business of engineers, etc. Registered office: 43, Chatsworth Road, Stratford, E.

ALLEN & SIMMONDS, LIMITED.—Capital £35,000 in £1 shares, to acquire the business carried on at the Thames Side Engineering Works, Reading, Berks, as Allen & Simmonds; to adopt an agreement with R. Allen and E. R. Simmonds, and to carry on the business of engineers, etc. Registered office: De Montford Road, Reading, Berks.

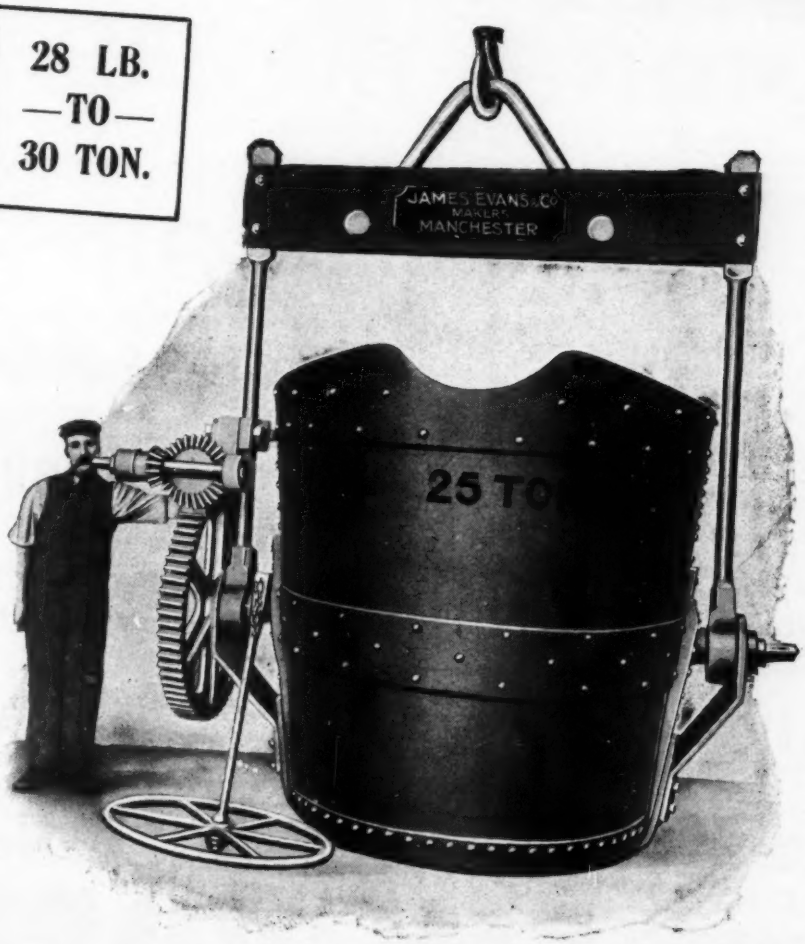
J. FIRMINGER & COMPANY, LIMITED.—Capital £2,500 in £1 shares (1,500 preference), to adopt an agreement with J. Firminger, jun., and to carry on the business of wholesale charcoal manufacturers and grinders, manufacturers of and dealers in foundry requisites, etc. Registered office: 61 and 63, Eltham Street, Walworth, S.E.

HODGSON HARTLEY (1909), LIMITED.—Capital £10,000 in £1 shares, to acquire the business carried on at Brookhouse Iron Works, Cleckheaton, Yorkshire, by Hodgson Hartley, Limited; to adopt an agreement with W. H. Armitage, C. H. Booth, B. Crowther and R. Potter, and to carry on the business of mechanical, electrical and hydraulic engineers, etc.

T. & C. CLARK & COMPANY, LIMITED.—Capital £70,000 in £10 shares, to take over the business of manufacturers of tinned and enamelled, cast and wrought iron hollow ware, ironfounders, etc., carried on at the Shakespeare Foundry, Wolverhampton, by C. F. Clark, B. O. Clark, and T. C. Clark, as T. & C. Clark & Co. Registered office: Shakespeare Foundry, Horsley Fields, Wolverhampton.

FOUNDRY LADLES.

28 LB.
—TO—
30 TON.



JAMES EVANS & CO., BRITANNIA WORKS, BLACKFRIARS, MANCHESTER.

TELEGRAMS—
"LADLES, MANCHESTER."
TELEPHONE—2297.

DEATHS.

—o—

MR. J. BRADSHAW, a director of Cooper Brothers, Limited, engineers, Bethesda Street Foundry, Burnley, died recently, aged 63 years.

MR. W. H. DAVIS, of Messrs. H. & W. Davis & Sons, ironfounders, etc., Pye Street, Portsmouth, died recently.

MR. W. ALEXANDER, works manager, London, Brighton and South Coast Railway Loco. Department, died at Brighton on February 6.

MR. R. LUKE, one of the founders of the firm of Luke & Spencer, Limited, emery-wheel manufacturers, Broadheath, died recently, aged 70 years.

MR. H. O. CURRY, of Newport, died last week, at the age of 44. The deceased was the assistant locomotive superintendent to the Great Western Railway at Newport.

MR. CHARLES R. JONES, one of the leading and best-known business men in Syracuse, New York, and secretary and treasurer of the Frazer & Jones Company, died recently in that city, aged 47 years.

MR. E. F. C. YOUNG, president of the Joseph Dixon Crucible Company, Jersey City, N.J., U.S.A., died recently at the age of 73 years. He was also president of the American Graphite Company.

THE death took place recently of Mr. F. G. Pearson, aged 52, of 43, Woodstock Road, Sheffield. The deceased was the head of the firm of F. G. Pearson & Company, edge tool manufacturers, Hope Works, Furnace Hill, Sheffield.

MR J. G. LOCKWOOD died at his residence, 1, Lorne Terrace, Stockton, on Tuesday. The deceased gentleman, who was well known in the steel trade on Tees-side, was a son of the late Mr. George Lockwood, J.P., twice Mayor of Stockton, and head of the shipbuilding yard now carried on by Messrs. Ropner & Sons. He carried on the iron foundry of Messrs. Mainwaring & Sons, Stockton, for 30 years, and was chairman of the Stockton Steel Foundry Company, Limited. He was also chief engineer and designer with Messrs. Dorman, Long & Company. The deceased was in his 59th year.

MR. G. E. BELLISS, of The Dell, King's Norton, and founder of the well-known engineering firm of Bellis & Morcom, died on February 14. Mr. Bellis was born on August 30, 1838, and, on leaving school, was apprenticed to Mr. Richard Bach, a mechanical engineer and boiler-maker in Broad Street, at the works now owned by Messrs. Piercy & Company. Shortly after the expiration of his articles in 1862 he acquired the business, which he carried on in partnership with Mr. J. J. Seekings. The latter subsequently retired, and Mr. Belliss continued the business single-handed for many years, under the style of G. E. Bellis & Company. At that time the firm manufactured high-pressure vertical fixed steam engines, contractors' locomotives, travelling portable engines, etc., but it was not long before Mr. Bellis turned his attention to the production of engines specially adapted for marine purposes, a branch of work which afterwards became the most important carried on by his firm. Increases in the business made it necessary for Mr. Belliss to obtain assistance, and he was joined by the late Mr. Alfred Morcom, the chief engineer at Sheerness Dockyard, who, in 1884, resigned his position under the Admiralty, and went to Birmingham. From that time the business in naval work was materially developed. In 1893 Mr. Belliss converted the concern into a private company, with himself as chairman, and Mr. Morcom as managing director. In 1899, when the demand for self-lubricating engines was exceptionally heavy, it became necessary to provide additional capital, and this was obtained by the issue of preference shares and debentures, and the business was henceforth known as Belliss & Morcom, Limited. Mr. Belliss retained the chairmanship of the company until 1904, when, on the advice of his medical attendant, he relinquished his active association with the concern.

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,
FIRE CLAY.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
STEEL MOULDERS' COMPOSITION, SILICA CEMENT.
J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR, nr. SHEFFIELD.
Telegrams: "LOWOOD, DEEPCAR"

The Old English Firm for Superior Quality and Cheapest
STRAW ROPES
PROCTOR BOWES & Co., Newcastle-upon-Tyne.
Write for Prices Immediately.
Telegrams: "PROCTOR BOWES, NEWCASTLE/TYNE." Telephones: NAT. 1683 and 4742 CENTRAL.

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ALUMINO THERMIC

REG. TRADE MARK.

WELDING PROCESS

— FOR —

BROKEN CASTINGS.

REPAIR SHOP

NOW OPEN.

ESTIMATES FOR WORK AND ILLUSTRATED PAMPHLET upon application to

THERMIT LIMITED,

27, Martin's Lane, Cannon Street, E.C.

ELDERS FOUNDRY COKE

AS SUPPLIED TO THE BRITISH ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From MOUNTFORD PHILLIPS & CO., Llantrissant.

Llantrissant, October 25th, 1904.

In reference to the Foundry Coke you have been supplying us with for the last six months, we have very great pleasure in letting you know that it has given every satisfaction, and that our Works Manager and Workmen give it the highest praise.

Elders Navigation Collieries, Ltd., Cardiff.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years :—

METALS.	End Feb., 1909.	End Feb., 1908.
Iron—Scotch pig warrants ton	53/1½	*56/6
—Middlesbro' warrants ton	47 0	50 5
—W.C. M/nos Bessemer ... ton	57 6	59 0
—Stock, Scotch ... tons	1,060	1 028
Copper—Chill bars, GMB ton	£56 12 6	£58 0/0
—Stock, Europe and afloat tons	52,239	22,175
Tin—English ingots ... ton	£131 0 0	£131 10 0
—Straits ... ... ton	£131 5 0	£128 7/6
—Stock, London, Holland, U.S.A., and afloat ...tons	20,912	15,247
Lead—English pig ... ton	£13 17 6	£14 2 6
Spelter—Ord. Silesian ton	£21 17 6	£21 5 0
Quicksilver (75lb)... bottle	£8 7 6	£8 4 6
Antimony—Regulus ... ton	£32 0/0	£35 0/0

* Settlement price.

CASTINGS.

In the Cleveland district the following are the nominal rates current for castings :—

	£ s. d.		£ s. d.
Columns (plain)	6 15 0	to	7 0 0
Pipes, 1½ to 2½ in.	5 2 6	to	5 7 6
,, 3 to 4 in.	4 15 0	to	5 5 0
,, 5 to 8 in.	4 12 6	to	4 15 0
,, 10 to 16 in.	4 12 6	to	4 15 0
,, 18 to 24 in.	4 12 6	to	4 15 0
Chairs	3 10 0	to	3 12 6
Floor plates (open sand)	3 0 0	to	3 5 0

SCRAP.

The quotations for scrap, subject to market fluctuations, are as follows: —Heavy wrought (mixed), £2 8s. 0d.; light wrought, £1 1s. 0d.; heavy cast, £2 7s. 0d.; all per ton f.o.b., London. Copper (clean), £51 0s. 0d.; brass (clean), £38 0s. 0d.; lead (usual draft), £12 15s. 0d.; tea lead, £11 5s. 0d.; zinc, £17 15s. 0d.; all per ton delivered merchant's yard.

MACHINE SPUN

STRAW ROPES

of usual standard qualities are as popular as ever, and now much reduced in price.

WOOD CORE ROPES

of all sizes also always in stock.

WILLIAM OLSEN,

Cogan Street, HULL.

WILLIAM OLSEN,

Cogan Street, HULL,

Importer and Manufacturer of

PLUMBAGO & BLACKING

FOR ALL PURPOSES.

All Founders practising economy should write for samples and quotations for carriage paid deliveries.

SILICA FIRE BRICK Co.,

OUGHTIBRIDGE.

GROUND GANISTER,

WET OR DRY.

Silco Cupola Bricks, 90 % Silica.

Better than Fire-clay Bricks for Cupolas.

Established 1863.

JAS. DURRANS & SONS,

PHŒNIX WORKS, PENISTONE, Near Sheffield.

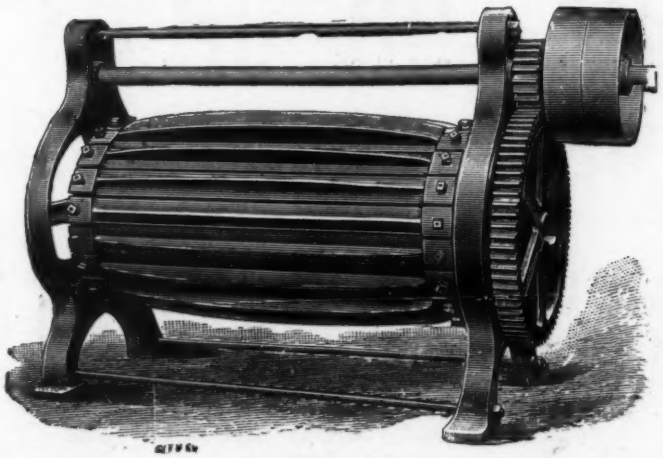
Manufacturers of all

FOUNDRY EQUIPMENTS,

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST.

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

IMPROVED FOUNDRY RATTLER or FETTLING DRUM.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD."

SEND for our CATALOGUE of

SECOND-HAND MACHINERY,

IN STOCK FOR IMMEDIATE DELIVERY.

ENGINES, BLOWERS, FANS,

LOAM MILLS, CUPOLAS,

BOILERS, CRANES,

WEIGHING MACHINES, Etc.,

SUITABLE FOR FOUNDRIES.

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ALBION WORKS, **SHEFFIELD.**

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SWIFT METALLIC STOPPING

THE NEW FOUNDRY CEMENT.

IT is used for filling up blowholes and sand holes in Cast Iron or Steel Castings.
IT is supplied in powder form and mixed for use with a little water to a stiff paste.
IT dries on a casting in 1 hour, and can be filed up bright in from 6 to 12 hours.
IT is specially useful to all Engineers, Machinists, Foundrymen, etc.
IT is of British Manufacture.

A Small Sample sent Post Free on Receipt of your Address, or a trial 1 lb. Tin Post Free on receipt of P.O. or Stamps for 1s. 4d.

THE SILENT MACHINE & ENGINEERING CO.,

2, Savile Street, SHEFFIELD.

THE BUYER'S GUIDE

Addresses and further information will be found by reference to the Firm's Advertisement.

Abrasive Wheels.
London Emery Works Co.

Air Compressors.
Jackman, J. W., & Co., Ltd.
Thwaites Bros., Ltd.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Electrically Driven).
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Steam).
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Belt).
Tilghman's Patent Sand Blast Co., Ltd.

Annealing.
Phillips, J. W. & C. J.

Ash Crushing and Washing Machines.
Phillips, J. W. & C. J.

Barrels (Tumbling).
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall, H. P., & Co.
Sonnenthal, Selig, & Co.
Tilghman's Patent Sand Blast Co., Ltd.

Barrows.
Durrans, J., & Sons.
Evans, J., & Co.

Bellows.
Durrans, Jas., & Sons.

Blacklead.
Durrans, J., & Sons.
Olsen, Wm.
Walker, I. & I.

Blowers.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Buffalo Forge Co., Ltd.
Davies, T. & Son.
Evans, J., & Co.
Honig & Mock, Ltd.
London Emery Works Co.
Marshall, H. P., & Co., Ltd.
Samuelson & Co., Ltd.
Sonnenthal, Selig, & Co.
Thwaites Bros., Ltd.
Ward T. W., Ltd.

Buffing and Polishing Machines.
London Emery Works Co.
Sonnenthal, Selig, & Co.

Casting Cleaners.
Durrans, J., & Sons.
Tilghman's Patent Sand Blast Co., Ltd.

Cement.
Dyson, J. & J.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Lowood, J. Grayson, & Co., Ltd.
Plasti-Kion Co.
Silent Machine and Eng. Co.

Chaplets and Studs.
Bush, Henry C.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles.
Motherwell, Wm., & Co.
Olsen, Wm.
Wilkinson, T., & Co., Ltd.

Charcoal.
Evans, J., & Co.
Walker, I. & I.

Charging Platforms.
Thwaites Bros., Ltd.

Coal Dust.
Cumming, Wm., & Co., Ltd.
Durrans, J., & Sons.
Walker, I. & I.

Coke.
Elders Navigation Collieries.

Coke Breakers.
Evans, J. & Co.
Jackman, J. W. & Co.
Phillips, J. W., & C. J.

Core Boxes.
Evans, J. & Co.
Jackman, J. W. & Co.

Core Compounds.
Bush, H. C.
Cumming, Wm. & Co., Ltd.
Durrans, J. & Sons.
Evans, J. & Co.
Jackman, J. W. & Co.
Olsen, Wm.
Wilkinson, Thos. & Co.

Core Gums.
Durrans, J. & Sons.
Walker, I. & I.

Core Making Machines.
Jackman, J. W. & Co.
Jones and Attwood.
London Emery Works Co.
Marshall, H. P. & Co.
Phillips, J. W. & C. J.

Core Ovens.
Evans, J. & Co.
Jackman, J. W. & Co.
London Emery Works Co.
Phillips, C. D.

Core Ropes.
Bush, Henry C.
City of London Wood Wool Co.
Durrans, J. & Sons.
Evans, J. & Co.
Olsen, Wm.
Wilkinson, T. & Co.

Core Vents.
Bush, Henry C.
Evans, J. & Co.
Olsen, Wm.

Cranes.
Ward, T. W., Ltd.

Crucible Furnaces.
Simplex Coke Oven and Engineering Co., Ltd.

Crucible Furnaces (Lift-out)
Phillips, J. W. & C. J.

Crucible Furnaces (Tilting)
Phillips, J. W. & C. J.

Crushing Mills.
Simplex Coke Oven and Engineering Co., Ltd.

Cupolas.
Davies, T. & Son.
Durrans, J. & Sons.
Evans, J. & Co.
Jackman, J. W. & Co.
London Emery Works Co.
Marshall, H. P. & Co.
Stewart, W. H.
Thwaites Bros., Ltd.

Cupola Linings.
Harris & Pearson.
Harrison, G. K., Ltd.

Emery and Glass Cloth and Glass Paper.
London Emery Works Co.

Fans.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Buffalo Forge Co.
Jenkins, W. J. & Co., Ltd.
Sonnenthal, Selig, & Sons.
Thwaites Bros., Ltd.

Firebricks.
Durrans, J. & Sons.
Dyson, J. & J.
Harris & Pearson.
Harrison, George K., Ltd.
King Bros.
Lowood, J. Grayson, & Co., Ltd.
Pearson, E. J. & J.
Silica Firebrick Co.

Foundry Blacking.
Bush, Henry C.
Cumming, Wm. & Co., Ltd.
Durrans, J. & Sons.
Evans, J. & Co.
London Emery Works Co.
Olsen, Wm.
Walker, I. & I.
Wilkinson, Thos. & Co., Ltd.

Foundry Brushes.
Bush, Henry C.
Durrans, J. & Sons.
Evans, J. & Co.
Hall, C.
Olsen, Wm.

Foundry Ladles.
Bush, Henry C.
Davies, T. & Son.
Durrans, J., & Sons.
Evans, J., & Co.
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Marshall, H. P., & Co.
McNeil, Chas.
Thwaites Bros., Ltd.

Foundry Rattlers or Fettling Drums.
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Evans, J., & Co.
London Emery Works Co.
Simplex Coke Oven Co. and Eng. Co., Ltd.

Foundry Sand.
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Jackman, J. W., & Co., Ltd.

Furnaces (Annealing).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Hislop, R. & G.
Phillips, J. W. & C. J.

Furnaces (Melting).
Davies, T., & Son.
Jackman, J. W., & Co., Ltd.
Phillips, J. W. & C. J.
Simplex Coke Oven and Eng. Co., Ltd.

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Durrans, J., & Sons.
Dyson, J. & J.
Lowood, J. Grayson, & Co.
Silica Firebrick Co.
Walker, I. & I.

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London Emery Works Co.
Sonnenthal, Selig, & Co.

Hammers (Steam).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Thwaites Bros., Ltd.

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Hoists.
Thwaites Bros., Ltd.

Loam and Sand Mills.
Durrans, J., & Sons.
Ward, T. W., Ltd.

Melting Furnaces (Oil-fired).
Phillips, J. W. & C. J.

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Swift, James & Son.

THE BUYER'S GUIDE.—*Continued.*

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Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
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Marshall, H. P., & Co.
McGregor Bros., Ltd.
Samuelson & Co., Ltd.
Simplex Coke Oven and Eng. Co., Ltd.
Whittaker, Wm., & Sons, Ltd.

Moulding Machines (Hand and Power).
Simplex Coke Oven and Eng. Co., Ltd.

Pig Breakers.
Evans, J., & Co.
Simplex Coke Oven and Eng. Co., Ltd.
Sonnenthal, Selig, & Co.

Pig-Iron.
Bradley & Sons, T. & I., Ltd.
Frodair Iron and Steel Co., Ltd., The
Grazebrook, M. & W.

Plumbago.
Bush, Henry C.
Cumming, Wm. & Co., Ltd.
Durrans, J., & Sons.
Evans, J., & Co.
London Emery Works Co.
Olsen, Wm.
Walker, I. & I.
Wilkinson & Co., Thos., Ltd.

Pneumatic Tools.
Marshall, H. P. & Co.
Simplex Coke Oven & By-products Co.

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London Emery Works Co.

Publications.
Eagland & Co., Ltd.
Griffin, Charles & Co., Ltd.

Pyrometers.
Phillips, J. W. & C. J.

Riddles.
Bush, H. C.
Durrans, J. & Sons.
Olsen, Wm.
Simplex Coke Oven and Engineering Co., Ltd.
Wilkinson, Thos. & Co., Ltd.

Sand Blast Apparatus.
London Emery Works Co.
Tilghman's Patent Sand Blast Co., Ltd.

Sand Driers.
Evans, J. & Co.
London Emery Works Co.
Simplex Coke Oven and Eng. Co., Ltd.

Sand Grinding Mills.
Evans, J. & Co.
Jackman, J. W. & Co., Ltd.
London Emery Works Co.

Sand Mixers.
Jackman, J. W. & Co., Ltd.
London Emery Works Co.
Phillips, J. W. & C. J.
Simplex Coke Oven and Eng. Co., Ltd.

Sand Riddling, Separating and Sifting Machines.
Evans, J. & Co.
London Emery Works Co.
Marshall, H. P. & Co., Ltd.
Simplex Coke Oven and Eng. Co., Ltd.
Sonnenthal, Selig & Co.

Sieves.
Durrans, J. & Sons.
Simplex Coke Oven and Eng. Co., Ltd.

Smiths' Hearths.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Marshall & Co., H. P., Ltd.
Samuelson & Co., Ltd.
Sonnenthal, Selig, & Co.
Thwaites Bros., Ltd.

Steel Moulders' Composition.
Dyson, J. & J.
Lowood, J. Grayson, & Co., Ltd.

Spades.
Durrans, J., & Sons.

Stone Flux.
Durrans, J., & Sons.

Stoppers and Nozzles.
Dyson, J. & J.

Straw Ropes.
Bowes, Proctor, & Co., Ltd.,
Olsen, William.

Testing Machines.
Evans, J., & Co.

Tuyeres (Firebrick).
Dyson, J. & J.
Lowood, J. Grayson, & Co. Ltd.

Welding.
Thermit, Ltd.

FOUNDRY EQUIPMENT.

INCLUDING

RAPID ECONOMIC CUPOLAS, 1 to 20 tons capacity.

SMALL EMERGENCY CUPOLAS, 5 to 15 cwts. capacity.

IMPROVED ROTARY CORE MACHINES, for cores $\frac{3}{8}$ in. to 7 in. diameter.

"LEEDS" DEAD LENGTH CORE MACHINES (Piston type).

TESTING MACHINES, for hardness, tensile and transverse tests.

GAS-FIRED CORE STOVES (Hislop System).

MOULDING MACHINES. MAGNETIC SEPARATORS.

PNEUMATIC CHIPPERS, HOISTS, RIDDLES, &c.

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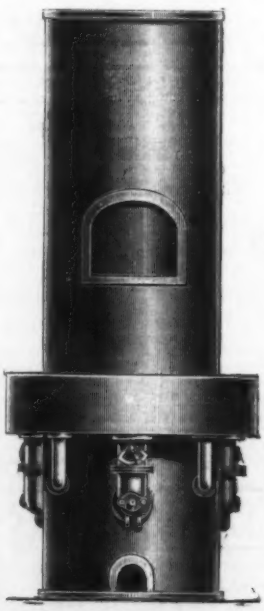

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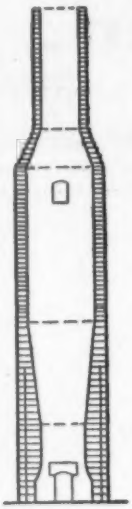

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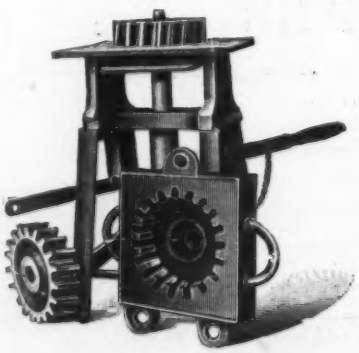

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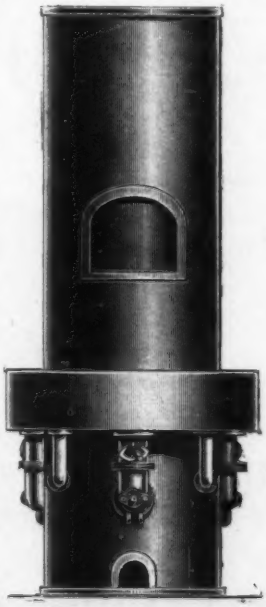

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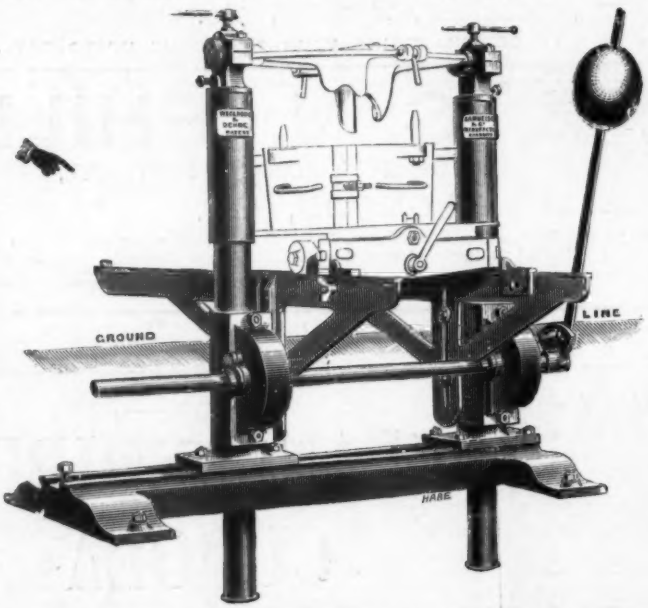

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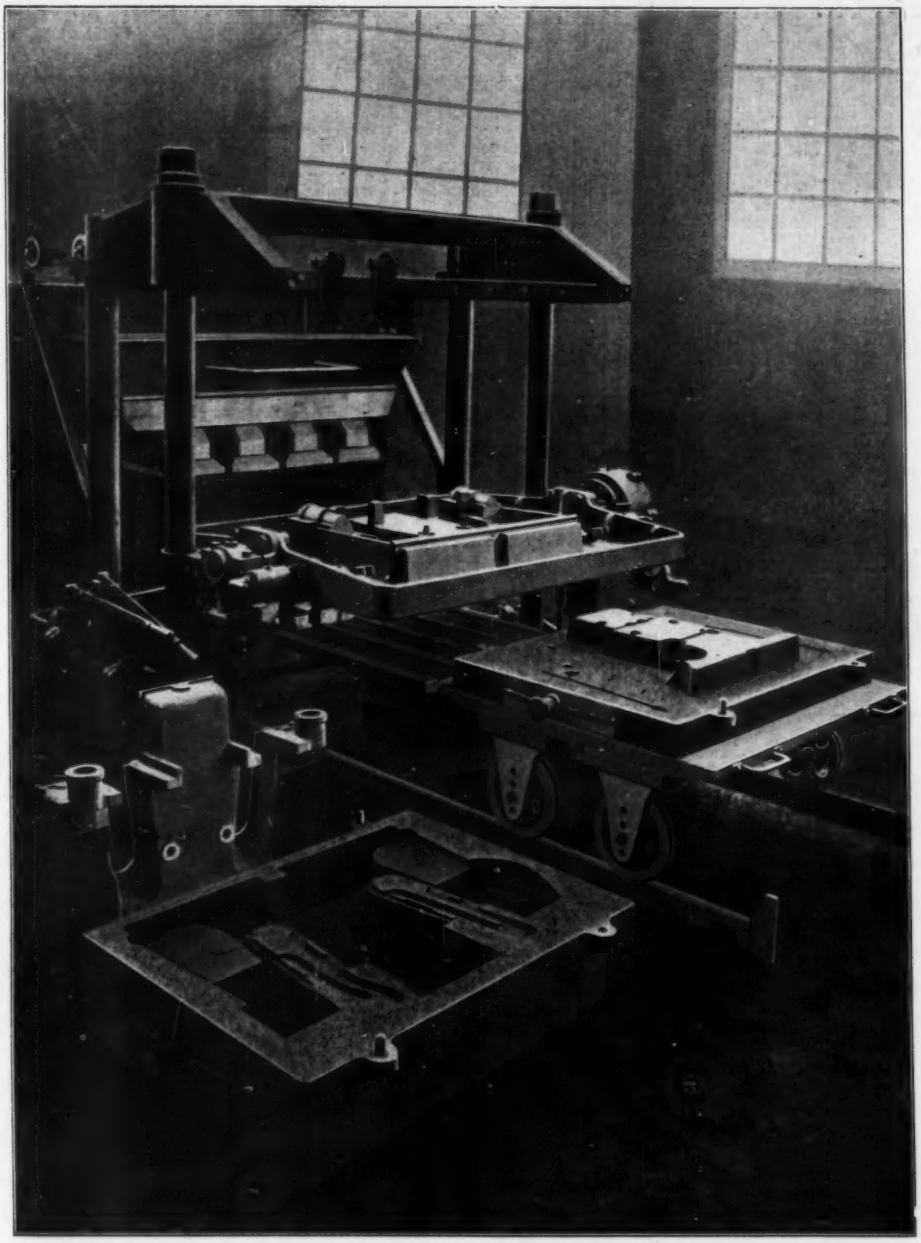

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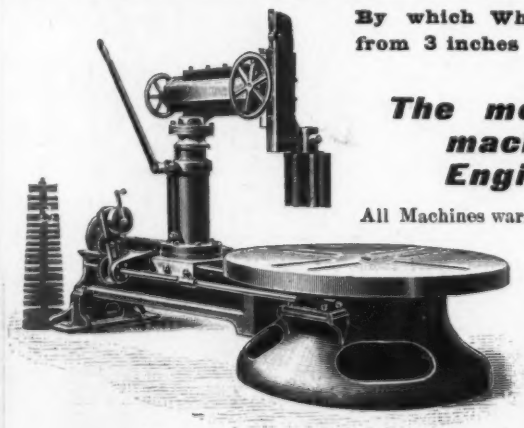

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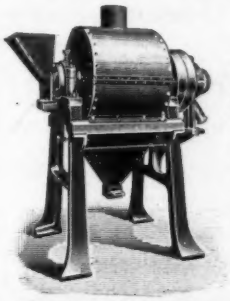

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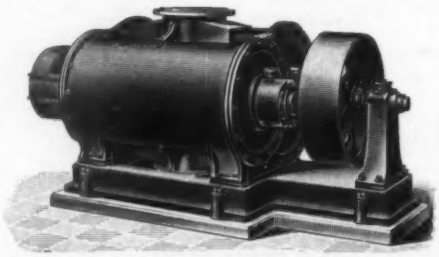

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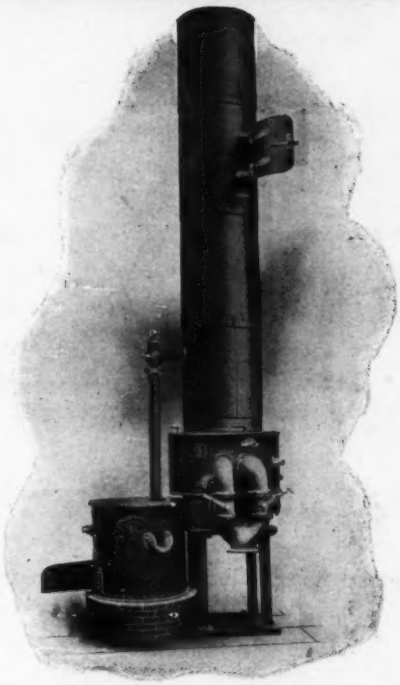

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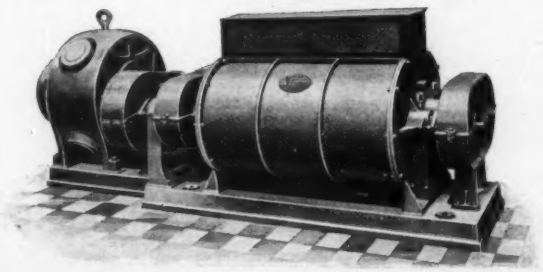

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